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INVESTIGATIONS WITH DDT AND OTHER NEW INSECTICIDES IN 1945

A Progress Report Prepared under the Direction of

DIVISION OF ENTOMOLOGY AND PARASITOLOGY

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FOREWORD

WHAT MIGHT BE CALLED *an insecticide crisis has occurred during the past three years and apparently will continue, in part, at least for another summer. The many war uses for inorganic compounds and the necessity for organic insecticides—especially nicotine, rotenone, and pyrethrum for the control of human disease-bearing insects—have created serious shortages for the control of insects injuring agricultural crops and domestic animals. These scarcities have resulted in a great production of new and promising insecticides. One of these—DDT—through government support and control, has been more thoroughly investigated and exploited than any other insecticide known. No other insecticide has had such wide and persistent publicity, such varied and thorough testing, such generous and extravagant support; neither has one heretofore had such effective and strict control, such complete protection, such tantalizing possibilities, and such mysterious insecticidal properties as DDT.*

The work of the Division of Entomology and Parasitology, University of California, with DDT has had to do chiefly with insects attacking agricultural crops, but some attention has also been given to the treatment of dairy barns, milkhouses, poultry houses, pigpens, and similar structures. Unfortunately, little investigational work could be done in the treatment of domestic animals for ectoparasites because of the lack of man power.

Certain experiments with DDT conducted on a small scale in 1944 assumed the proportions of large demonstrations in 1945. Tests for the control of lygus bugs in various parts of the state included some 1,000 acres of alfalfa, and considerable areas of baby lima beans and cotton. Larger-scale experiments were also conducted with onion thrips on onions, grape leafhopper, pear thrips and other thrips, codling moth and Catalina cherry moth on walnuts, cankerworms on apricots, various aphids, and the effects of DDT on honeybees and wild bees as pollinators of alfalfa.

In most of these tests, DDT proved to be very effective. Regardless of these extraordinarily promising results, the Division is still reluctant to give this new insecticide unqualified endorsement until certain doubtful points are further clarified. These include: (1) Satisfactory removal of residue on fruits and vegetables consumed by humans, and on alfalfa and pea straw, cornstalks, and other crop materials fed to domestic animals. (2) Better understanding of the absorption and retention of DDT within plant and animal tissues. (3) Sufficient experimental investigations to fix the minimum dosages in order to reduce amounts of residue and eliminate the hazards of poisoning. (4) Further investigation of the possibilities of combining DDT with other insecticidal materials. (5) Better methods of application to prevent the drifting of dusts outside the areas being treated.

Other promising insecticides, including sabadilla, D-D, DDD, and EDB, were also included in the investigational program of the Division, and are reported upon herewith.

There is also great need for more extended research work on the residual effects of these new insecticides under wider climatic conditions, and on the prevention or removal of undesirable or harmful residues, and there is equally as great a need for analytical chemical research on absorption of DDT by plant and animal tissues.

The work here reported is to be considered only as a progress report. The information on results of projects to date is being made available at this time because of the great interest in DDT and other new insecticides.

E. O. ESSIG

Division of Entomology and Parasitology.

CONTROL OF LYGUS BUGS ON ALFALFA SEED CROPS WITH DDT AND SABADILLA[1]

A. E. MICHELBACHER,[2] RAY F. SMITH,[3] AND N. L. McFARLANE[4]

FEEDING by lygus bugs (*Lygus hesperus, L. elisus,* and *L. oblineatus*) is one of the most important factors affecting the yield of seed in alfalfa fields. These insects, in both nymphal and adult stages, suck the plant juices. When populations are high, they cause severe losses, when feeding, by injecting toxins which cause a blasting of buds, stripping of flowers, and shriveling of seeds. In 1944, DDT (dichlorodiphenyl-trichloroethane) was shown to be very effective in controlling lygus bugs on alfalfa seed crops.[5] Because of this result, further and more extensive investigations were undertaken in 1945 along with limited experiments with sabadilla. Studies in California were conducted in the Sacramento and San Joaquin valleys, at Hemet, and in the Palo Verde Valley. The action of the insecticide was studied under a wide variety of climatic conditions in those parts of the state where the production of alfalfa seed is important. Dust mixtures containing from 0.5 to 10 per cent of DDT were used. The action of different carriers upon the effectiveness of DDT was also studied.

EXPERIMENTS WITH DDT

Experimental Methods.—Practically all of the investigations with DDT were conducted on a commercial experimental basis. Wherever possible, only a portion of a carefully selected field was treated; the remainder of the field was left for a check. Usually not less than 10 acres were treated, in order to minimize the problems caused by migrating adult lygus bugs. If at all possible, the treated area was located to avoid drift of insecticides over the check area. DDT in a dust carrier was used in all of the commercial experimental studies. In lowland middle California, applications were made with power-driven ground dusters and with airplanes. At Hemet all dusting was done with a ground machine, while in the Palo Verde Valley all applications were made by airplane.

The trends of the lygus-bug populations were observed in all fields studied. These were determined by sweeping the fields with an insect net.[6] Each field was surveyed a number of times, usually during the growth period from pretreatment to the time the crop was nearly mature. Sufficient stations were

[1] Received for publication January 22, 1946. The authors wish to acknowledge the assistance of O. G. Bacon, E. G. Linsley, J. W. MacSwain, G. L. Smith, V. O. Osterli, and of Fred Platt of the Riverside County Agricultural Commissioner's Office, during the course of field work. B. A. Olson at Blythe, M. A. Perry of Hemet, and H. A. Hannesson of Ryer Island, were helpful in making arrangements for the experimental work.

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[5] California Agricultural Experiment Station. Investigations with DDT in California, 1944. (A preliminary report prepared under the direction of the Division of Entomology and Parasitology.) (Lithoprinted.) 33 p. March, 1945.

[6] The frame of the net was an ellipse, with a major axis of 15 inches, and a minor axis of 13 inches.

selected throughout the treated and the check areas to give an adequate indication of the population; at each station either 2 or 5 sweeps were taken. Both nymphs and adults were counted, and an attempt was made to survey fields at an interval not to exceed a week to 10 days.

Population Trends of Lygus Bugs.—The typical population trend of lygus bugs during the growth of a seed crop is rather characteristic for most fields.

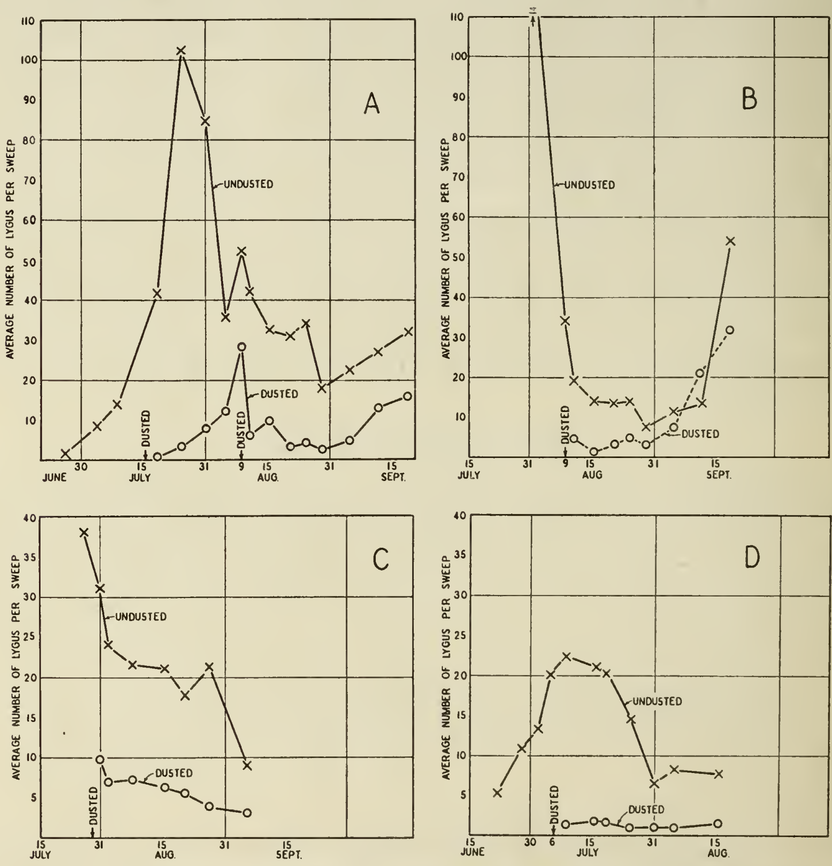

Fig. 1.—Typical population trends of lygus bugs in dusted and undusted portions of four alfalfa seed fields in lowland middle California.

It usually starts at a low level, rises rapidly to a peak, then is followed by a decline about as steep as the rise. The maximum population usually coincides with the period of full bloom. The marked decline in the population which then occurs may be attributed to a number of factors. Important among these are probably competition, action of predators and parasites, and the condition of the alfalfa which is made less favorable, in part, by the feeding of lygus bugs and by the drying of the plants as maturity is reached.

The length of time required for the population trend to complete the cycle varies widely. In some fields it occurs in a period of a few weeks; in others it may take as long as 2 months. The length of time is largely dependent upon

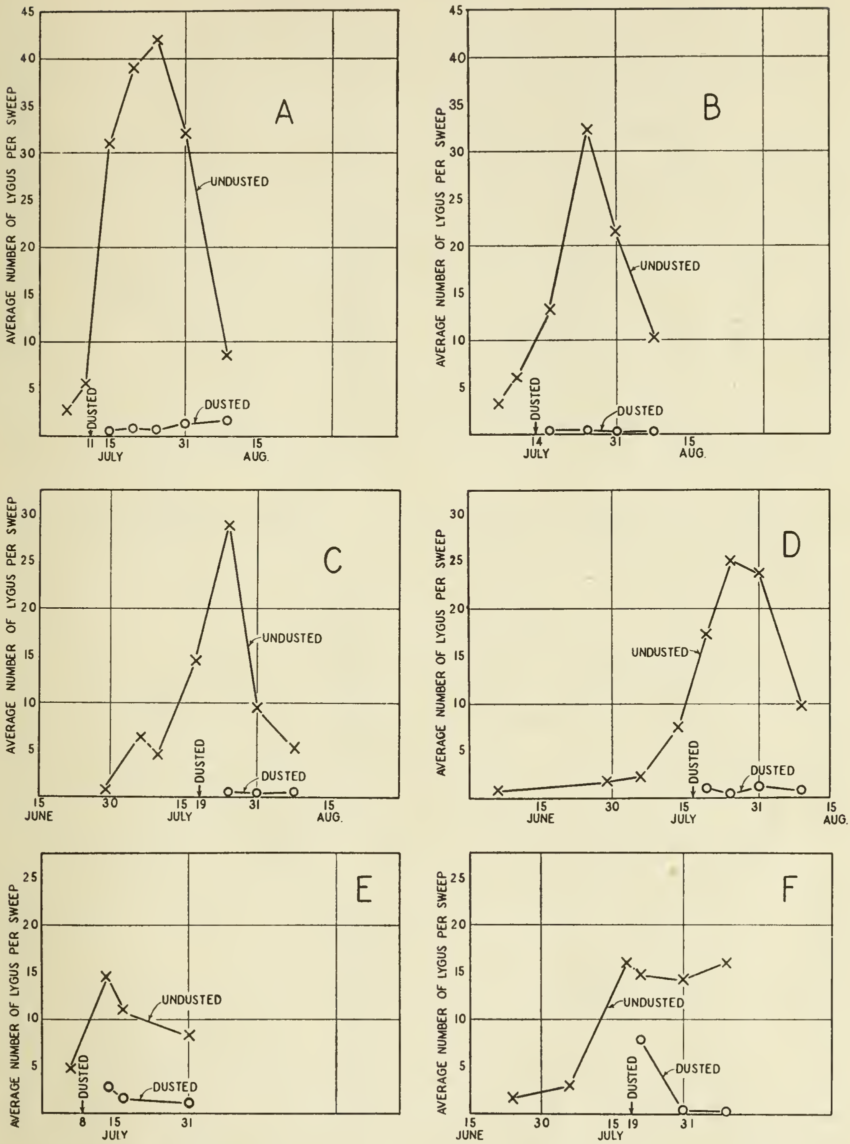

Fig. 2.—Typical population trends of lygus bugs in dusted and undusted portions of six alfalfa seed fields at Hemet.

the conditions under which the alfalfa is grown. Temperature and moisture conditions in alfalfa fields are important considerations. Under dry conditions, the cycle is likely to be of short duration because the alfalfa dries up. Thus, the period of time necessary for the population to rise and fall is usually longest where a field is irrigated or where the water table is sufficiently high to furnish moisture for the alfalfa. High temperatures not only speed up the development of lygus bugs, but, in the absence of sufficient moisture,

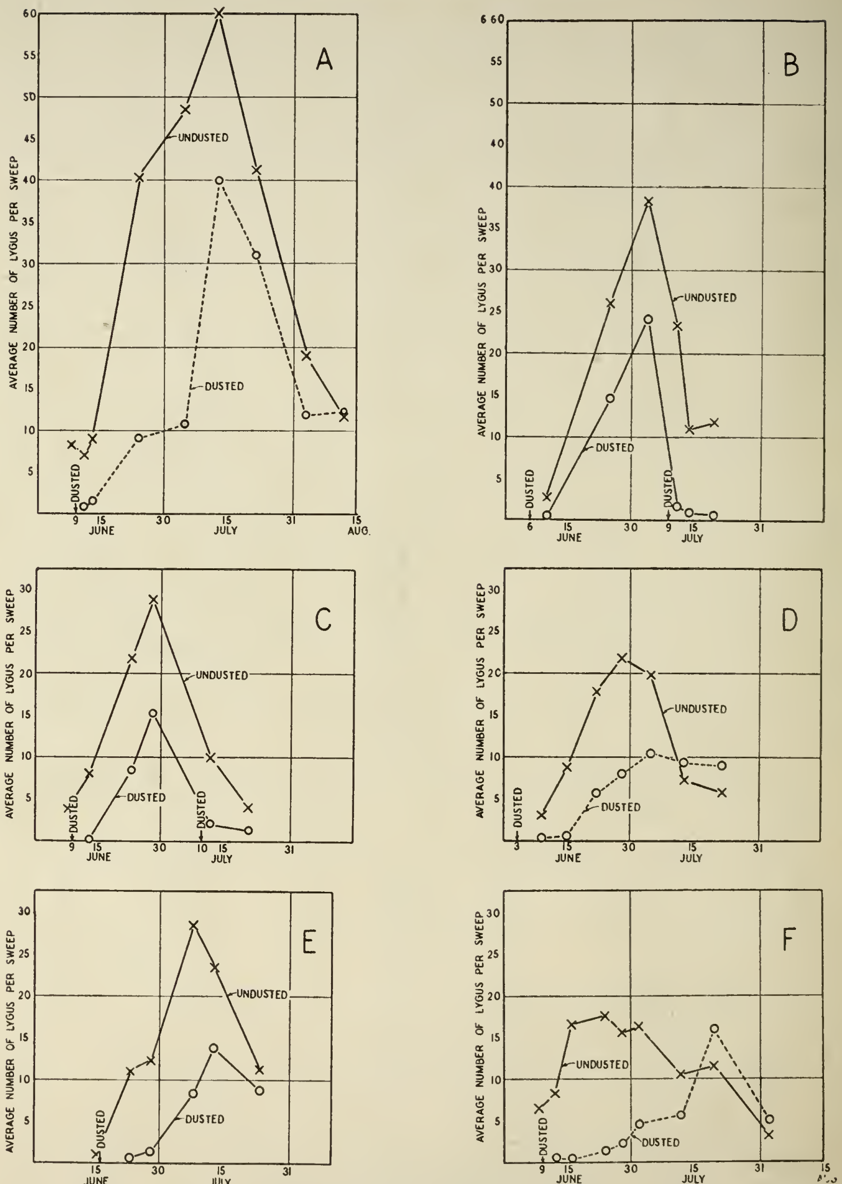

Fig. 3.—Typical population trends of lygus bugs in dusted portions of six alfalfa seed fields in the Palo Verde Valley.

accelerate the drying up of the alfalfa fields themselves. Although not always true, the largest populations and highest peaks occur in those fields where a relatively long period is needed to complete the normal population cycle. In general, the period necessary to complete the cycle was longest in the seed fields of middle California, relatively short in the fields of the Hemet area, and short to rather long in the fields of the Palo Verde Valley. The length

of time necessary to complete the cycle has an important bearing upon the proper timing of dust application. This is discussed in a later section. Typical populations of lygus bugs encountered in the undusted portions of the fields under study in 1945 are shown for lowland middle California in figure 1, for Hemet in figure 2, and for the Palo Verde Valley in figure 3.

Factors Influencing Timing of Dust Applications.—Lygus bugs are not likely to cause any material damage until numerous enough so that at least an average of 5 bugs can be collected to a sweep of an insect net. Severe loss of seed is not likely to result until the population reaches a much higher level. Under certain conditions, populations may develop to a point where a complete loss of seed will result (fig. 1, *A* and *B*). Dusting to control the pest is probably not justified under California conditions, unless it appears probable that the number of bugs will reach a peak of about 15 per sweep or more. It is not always an easy matter to determine just when or if a field should be treated, but the following points should be considered in making the decision:

1. Is the stand and expected yield sufficiently good to justify the cost of treatment?
2. Probable size of population of lygus bugs as affected by: vegetative condition of the alfalfa; crops grown in adjacent fields; probable length of period needed to produce a crop of seed; probable harmful effect of dusting upon beneficial insects.
3. Disposition to be made of the straw following harvest.

It is obvious that a certain minimum stand of alfalfa is necessary before the cost of treatment can be justified. Fields may be too weedy or contain too many bare spots to make treatment worth while, or growth conditions may be unsuitable to produce a satisfactory yield. The population of lygus bugs must attain a certain minimum density to justify treatment. So far the present writers have been unable to develop an accurate means of predicting the size that a population of the bugs will attain. With present knowledge, the population trend can be determined only by making frequent surveys of any field in question. It is known that parasites and predators, the vegetative condition of the alfalfa, and dryness are important factors in influencing the size of populations. Large populations are more likely to develop in fields that make strong growth than in those where the growth is poor. Likewise, population increases will be greater in fields where growth of the seed crop is normal than in fields that dry up rapidly from lack of moisture.

The length of time required to produce a seed crop in any particular field is one of the most important factors that must be considered. If the period is long, the development of a large population of bugs is likely, and the timing of a dust application is exceedingly important. Where the period is short, the timing of the dust application, although important, is less so than where the period to produce a seed crop is long. Ideally, the dust should be applied before the alfalfa comes into bloom, at which time the insecticide is not likely to have any harmful effect upon either wild bees or honeybees. Presumably, where a seed crop is produced in a short time, dusting in the prebloom stage should result in very satisfactory control of lygus bugs and should insure nearly maximum seed yields. However, at this stage of growth populations are frequently very small, and dust sometimes might be applied to fields

where treatment would not be necessary. In most cases at least, it would appear best to delay dusting until an average of about 10 bugs can be collected to the sweep of a net. A population of this size is usually not reached until a field is well into bloom. Where a dust is applied too early in the growth of a crop, there is danger that the effective residual action of the DDT will wear off before the crop is made, and that much seed will be lost because of destructive populations of lygus bugs that subsequently develop. This is almost certain to occur when the period necessary to produce a seed crop is long. Where this is the case, dusting should be delayed as long as possible; even so, a second dusting may be necessary to insure best control. Under such circumstances, the second application will always be made during the blooming period.

The condition of surrounding fields must be taken into consideration in timing the application of dust. If an adjacent seed crop such as sugar beets is about to be harvested, the dusting should be delayed, if at all possible, until after the harvest. In this way any migration of lygus bugs from the harvested area into the field will occur before the dusting. For the same reason, dusting should be delayed until after surrounding hayfields are cut. This precaution should also be followed in order to avoid a drift of dust over a hayfield about to be harvested. Large migrations of adult lygus bugs from a hayfield into a dusted field may make desirable a second treatment. This is well illustrated in figure 1, *A*, where the steep rise in the population of lygus bugs, immediately before the second application of dust, was due to a heavy migration of bugs from an adjacent heavily infested hayfield that had just been cut.

Under many conditions it is desirable to dust fields after they have come into bloom. This brings up the question of how harmful dusting is to the wild bees and the honeybees. Many believe that not a great deal of harm is done. This matter has been investigated by staff members of the Division of Entomology and Parasitology and is reported upon by E. Gorton Linsley[7] and J. E. Eckert[8] in accompanying papers in this publication. It is sufficient to say that following the dusting with DDT of fields in bloom, suppression of the bee population occurs for a few days and is followed by a rise in numbers. Some days after dusting, the bees in a dusted field may exceed those found in adjacent undusted areas. The reason for this is that in the dusted area there is little or no blasting of the bloom by lygus bugs and, as a result, the bloom is in excellent condition for bees to visit. Under extreme conditions, the population of lygus bugs may become so large that all the bloom in undusted areas may be blasted, with neither pollen nor nectar left for the bees to collect. Therefore, where populations of lygus bugs are large, it could be argued that dusting with DDT is indirectly beneficial to bees because it insures an ample honey flow.

Effect of DDT on the Predator Populations.—Observations were made on the effect of DDT on the predator populations in alfalfa fields. Because of limited time, it was not possible to make any quantitative studies. However, ladybird beetle populations were nearly eliminated. This was not the case with a number of hemipterous predators. A number of these appeared to be

[7] Linsley, E. Gorton. Effect of DDT on insect pollinators of alfalfa (p. 18–22).
[8] Eckert, J. E. Effect of certain insecticides on beekeeping (p. 22–26).

less affected by DDT than was the population of lygus bugs. Important in this group were *Geocoris* spp. (big-eyed bugs), *Nabis ferus* (common damsel bug), and anthocorids (minute pirate bugs). Numerous cases existed where these predators appeared to be noticeably more abundant in the treated than in the check areas. The reason for this is not known, but may have been due to the fact that DDT killed many of their enemies. In one case, at least, a very large *Geocoris* population developed in the treated area. It became so large that it finally overflowed into the check area, where it was probably important in reducing the population of lygus bugs. The population trend of lygus bugs for this field is plotted in figure 3, *F*. The overflow *Geocoris* population probably accounts for the somewhat small numbers, and the flattened, rather than sharp, peak found in the population trend curve for the check area.

Although these hemipterous predators are less affected by DDT than are lygus bugs, some observations were made which indicated that they were more and more affected as the dosage of DDT was increased. Therefore, it would appear that the DDT dosage should be held to the absolute minimum that will give satisfactory control of lygus bugs.

Discussion of Dusts Used.—From the investigation it would appear that exceptionally good control of lygus bugs can be expected when the amount of actual DDT used ranges from about 1 to 1½ pounds per acre. Considerable evidence was obtained which indicated that the carriers used influenced the killing action of the DDT. In 1944 a very good kill was obtained with a 3 per cent DDT-pyrophyllite dust applied at approximately 28 pounds per acre. In this past season, a 3 per cent DDT-talc dust, applied at approximately the same rate, did not give an initial kill approaching that of the DDT-pyrophyllite dust, but the residual action appeared to be as good, and the resultant control satisfactory. One of the qualities of pyrophyllite which might distinguish it from talc is its more abrasive character, which may enable the insecticide to make better contact than that which occurs when talc is used. Some work was also done with sulfur as the carrier. Sulfur may increase the effectiveness of DDT over that obtained with talc, but this supposition needs to be further investigated. A 4 per cent DDT-fused sulfur mixture was a very effective material. Whether such a dust is more effective than a mechanical DDT sulfur mixture remains to be determined. Some injury to open blossoms occurred when sulfur was used during the blooming period, but in no case did it appear to be of a serious nature.

In most of the work, dusts containing 5 per cent DDT were applied at approximately 30 pounds to the acre. Those dusts containing 3 per cent DDT were applied at 30 to 50 pounds per acre. The 4 per cent DDT-fused sulfur dusts were used at the rate of approximately 30 pounds per acre.

The compounding of dusts containing DDT may have a very important influence upon the effectiveness of the DDT. In one test, a specially compounded dust that contained only 0.5 per cent of DDT was used. It gave surprisingly good control when applied at the rate of approximately 40 pounds per acre. The results of this test are plotted in figure 1, *B*. Although the dust was applied after the population of lygus bugs had started to decline, the reduction it obtained, and its apparent satisfactory residual action recommend this material for further testing.

Relative Effect of DDT upon Adults and Nymphs.—Results in 1944 indicated that DDT was more effective in killing the nymphs of lygus bugs than the adults. These observations were substantiated by general field observation during the past season. Moreover, populations that followed dusting usually consisted almost wholly of adults; nymphs were usually not encountered in numbers until a week or more after the treatment was applied. It does not seem possible that migration could account entirely for this result.

Means of Application.—Satisfactory control of lygus bugs was obtained where dusts were applied either by ground machine or by airplane. Frequently, there was so much drift that excellent control of lygus bugs resulted for several irrigation checks on the leeward side of a dusted plot. Where this happened, usually rather poor control would result in the first two irrigation checks of the dusted area on the windward side. Some of the dusting by airplane is very poorly done; because of this and extensive drift, it is believed that ground machines should be used wherever possible. Further, ground machines should be equipped with hoods to hold the drift to a minimum. It goes without saying that dusting should be done only when there is a minimum amount of air movement.

Seed Yields.—Seed yields were obtained for a number of fields. These data are shown in table 1, with information concerning the amount of dust and the method of application. Some marked increases in yields were obtained, in certain cases exceeding 100 per cent. Also, some fields showed little or no increase in yield. The population curves of lygus bugs for two such fields are plotted in figure 2, *E* and *F*. In both cases, it should be noted, the peak population of lygus bugs for the undusted portion of the field reached only about 15 per sweep.

Conclusions Drawn from the DDT Experiments.—DDT is a very effective insecticide for the control of lygus bugs on alfalfa seed crops. It appears to be a safe material, but further large-scale experimental commercial tests are necessary before unqualified recommendations can be made. Although DDT does not appear to be too harmful to wild bees or honeybees, further studies are necessary to determine this point.

The timing of applications is very important. This can probably best be done if the work is carried out under entomological supervision. In most cases, at least, dust applications apparently can be safely delayed until an average of about 10 lygus bugs is collected to the sweep of an insect net. From present knowledge it appears that, in most cases, the best control will result if dusting is delayed until the alfalfa is in bloom. However, there were some cases where dusts were applied when the population was small, before bloom, that resulted in good control (fig. 3, *D* and *E*). There were other instances where a delay in the application of dust would probably have resulted in much better control (fig. 3, *A, B,* and *C*). The normal population trend during growth of a seed crop is marked by a rather rapid rise of the population to a peak which is reached at about the time the alfalfa is in full bloom. This rise in population is followed by an abrupt decline. A properly timed dusting should be applied to eliminate, or to suppress the population during the period of most rapid build-up. As already stated, this period of high density of lygus bugs can best be suppressed if a dust is applied when the population reaches

TABLE 1

YIELD OF ALFALFA SEED OBTAINED FROM FIELDS DUSTED WITH DDT

Per cent of DDT in dust	Approximate pounds of dust applied per acre	Number of applications	Stage of bloom at time of treatment	Pounds of No. 1 and No. 2 clean seed per acre: Check	Pounds of No. 1 and No. 2 clean seed per acre: Treated	Increase, over check, in pounds per acre	Per cent of increase	Graphs illustrating lygus bug populations
Palo Verde Valley								
5	30	1	Late bloom........	181.5	428.8	247.3	136.25	
10	30	1	Late bloom........	181.5	385.9	204.4	112.61	
5	30	2	Early and late bloom...........	302.1	489.5	187.4	62.03	Fig. 3, *C*
5	30	2	Prebloom and late bloom...........	300.5	479.6	179.1	59.60	Fig. 3, *B*
3	30	1	Late bloom........	181.5	360.4	178.9	98.56	Fig. 3, *E*
5	30	1	Prebloom.........	376.7	500	123.6	32.81	Fig. 3, *D*
5	30	1	Early prebloom...	158.8	267.2	108.4	68.26	Fig. 3, *A*
3	30	1	10 days prebloom..	171.3	252.8	81.5	47.57	
5	30	1	Full bloom........	227.8	300.1	72.3	31.73	Fig. 3, *F*
5	30	1	Full bloom........	136.5	183.4	46.9	34.35	
3	30	1	Full bloom........	133.5	177.4	43.9	32.88	
5	30	1	Full bloom........	133.5	176.6	43.1	32.28	
5	30	1	Late bloom........	85.0	118.4	33.4	39.29	
10	30	1	Late bloom........	85.0	105.9	20.9	24.58	
3	30	1	Late bloom........	85.0	99.4	14.4	16.94	
Hemet Valley								
5	30	1	Full bloom........	148.1	326.2	178.1	120.2	Fig. 2, *C*
5	30	1	Early bloom......	149.4	267.9	118.5	79.2	
5	30	1	Early bloom......	147.1	248.6	101.5	68.7	Fig. 2, *A*
5	25	1	Early bloom......	174.4	275.8	101.4	58.0	
5	40	1	Full bloom........	98.7	180.4	81.7	82.8	Fig. 2, *B*
5	30	1	Early bloom......	295.6	349.3	54.2	18.4	Fig. 2, *D*
5	25	1	Early bloom......	138.6	181.4	42.8	30.9	
5	..	1	Late bloom........	140.3	153.8	13.5	9.6	Fig. 2, *F*
5	30	1	Full bloom........	78.9	88.3	9.4	11.9	
5	30	1	Early bloom......	201.7	210.1	8.4	4.1	Fig. 2, *E*
Lowland middle California								
4	30	2	Full bloom and late bloom......	no seed	411.5	.....	.....	Fig. 1, *A*
4*	30	1	Late bloom........	94.7	334.4	239.7	252.0	Fig. 1, *C*

* Following the first cutting, 300 pounds of superphosphate were applied per acre to the section of the field treated with DDT.

about 10 per sweep, although there are cases (see fig. 1, *A*) where dusting is best delayed until even a higher population occurs.

Marked increases in yields have resulted even where a dust has been applied after the population of lygus bugs has reached its peak (see fig. 1, *C*). In this case the increase in yield over the check was 252 per cent.

In this investigation there were fields where an unnecessary second application of dust was made (fig. 3, *B* and *C*). A second dusting would not have been considered had the first application been delayed until 10 lygus bugs to a sweep could have been taken.

Until more information is available, it is believed that the best results will be obtained if a 5 per cent DDT dust is applied at 30 pounds per acre. A 3 per cent dust should be used at from 40 to 50 pounds per acre, and a 4 per cent DDT-fused sulfur dust at 30 pounds per acre. It may be possible to compound dusts in some manner to increase the effectiveness of DDT so that the actual amount of material needed per acre can be reduced below the figures given above. Improved means of application should also permit reduction in the above dosages.

Although lygus bugs cause serious losses of alfalfa seed, many fields exist where the population does not develop to a point which justifies dusting.

Pending more detailed study on residue, the feeding to livestock of straw from fields dusted with DDT is not recommended.

EXPERIMENTS WITH SABADILLA

Some limited experimental commercial control using sabadilla dusts against lygus bugs attacking alfalfa seed crops was conducted in the Palo Verde Valley and at Tracy, in the season of 1945. In the Palo Verde Valley all applications were made by airplane, while at Tracy a single application was made with a ground power duster.

The experimental methods used in the investigation with sabadilla were the same as those given under the preceding section "Experiments with DDT." In all cases the dust was applied after the fields were in bloom. In the Palo Verde Valley a 10 per cent dust (containing 20 per cent sabacide) was used, applied at rates that ranged from 40 to 63 pounds per acre. At Tracy a 20 per cent dust was applied at the rate of 35 pounds per acre.

It was observed that sabadilla had a harmful effect upon the bees that visited the freshly dusted fields. The bees were observed buzzing about on the ground, but this adverse action of the insecticide upon the bee population probably did not last for more than a day or two.

Seed yields were taken in two cases. In one instance, in the Palo Verde Valley, where a 10 per cent dust was applied at the rate of 40 pounds per acre, the treated area showed an increase of 2 per cent of No. 1 and No. 2 recleaned seed over that of the check. This increase is so small that it is probably of no significance. In another field where the insecticide was applied at the rate of 63 pounds per acre, there was a 24 per cent increase in the amount of recleaned No. 1 and No. 2 seed. Through a misunderstanding, seed yields were not obtained in the field treated with a 20 per cent sabadilla dust at Tracy. However, the grower observed harvest operations rather carefully and estimated that the area treated with sabadilla produced approximately 25 per cent more seed than the check. The population trends of lygus bugs for the treated and check areas at Tracy are shown in figure 4. These trends indicate that the treated area should have outyielded the check, and that the grower's estimate was probably close to the actual increase.

Although these investigations would indicate that DDT is more effective in controlling lygus bugs on alfalfa than is sabadilla, the latter material should be further investigated. The main advantage of DDT over sabadilla is its residual action in killing lygus bugs. With sabadilla, residual action does not occur and there may be a very rapid increase in the population of

lygus bugs even shortly after the insecticide is applied. This disadvantage might be corrected if a second application of dust were made about a week after the first. This procedure would probably kill the nymphs that hatched after the first treatment and any adults that migrated into the field. A dusting program of this nature should be tested. Also, a further study of the action of sabadilla on wild bees and honeybees is desirable.

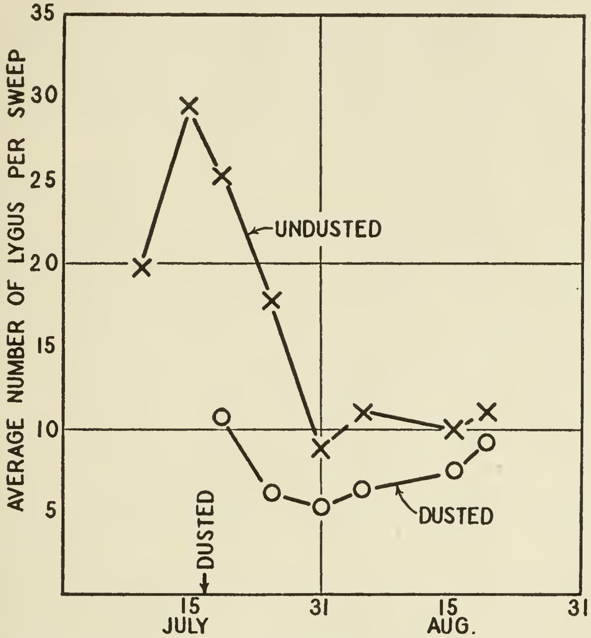

Fig. 4.—Population trends of lygus bugs for dusted and undusted plots in an alfalfa seed field at Tracy.

EFFECT OF DDT ON INSECT POLLINATORS OF ALFALFA[9]

E. GORTON LINSLEY[10]

Agronomists now generally agree that, as far as the commercial varieties of alfalfa now in use are concerned, seed setting requires tripping and cross-pollination by insects. In view of the promise shown by DDT in 1944 trials for the control of lygus bugs on alfalfa seed crops, it was deemed advisable to determine what effect, if any, applications of DDT might have upon insect pollinators. Studies were therefore undertaken in connection with the extensive control experiments reported by Michelbacher, Smith, and McFarlane in a companion paper.[11]

Field Investigations.—In the course of these studies, it was first necessary to determine what insects were of importance in alfalfa pollination in the areas under consideration, namely, Hemet Valley, Palo Verde Valley, northwestern San Joaquin Valley, and the lower Sacramento delta region. Although the results of this aspect of the study are reported elsewhere, they may be summarized here. Based upon the season of 1945, it would appear that: (1) The only significant insect agents of pollination are bees, no other insects having been observed to trip alfalfa flowers consistently. (2) In each of the areas involved, the major portion of the tripping and cross-pollination was accomplished by wild (solitary, nonsocial) bees. (3) In the Hemet Valley, 19 species were involved; in the Palo Verde Valley, 12 species; in the northwest San Joaquin Valley, 14 species; and in the Sacramento delta region, 13 species—although more extensive studies would undoubtedly increase this number substantially. (4) Honeybees were present in varying numbers in all fields, but both the percentage and the total numbers of pollen collectors compared unfavorably with the wild bees. (5) Bumblebees, although individually more efficient than honeybees, were inferior to other wild bees and were usually not abundant enough to be regarded as important factors in alfalfa pollination.

Since the selection of the fields, design of the field tests, and method of application of the insecticides have been described, as mentioned above, by Michelbacher, Smith, and McFarlane, they need not be repeated here. Observations upon bees were made in all of the fields used in the experiments and periodic population samples were taken in about half of them. These were based upon samples taken in counts from 25 broad sweeps with a net[12] across the blossoms while the collector moved rapidly through the field, taking about two strides between each sweep. From 8 to 20 such 25-sweep counts were taken in each field, according to its size. The advantages of this method over various

[9] The writer wishes to express his sincere appreciation to J. E. Eckert, A. E. Michelbacher, N. L. McFarlane, R. F. Smith, J. W. MacSwain, and M. A. Perry, for advice and assistance in field work; and to Fred Platt of the Riverside County Agricultural Commissioner's Office for assistance in relation to problems associated with the honeybee.

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[11] Michelbacher, A. E., Ray F. Smith, and N. L. McFarlane. Control of lygus bugs on alfalfa seed crops with DDT and sabadilla (p. 7–18).

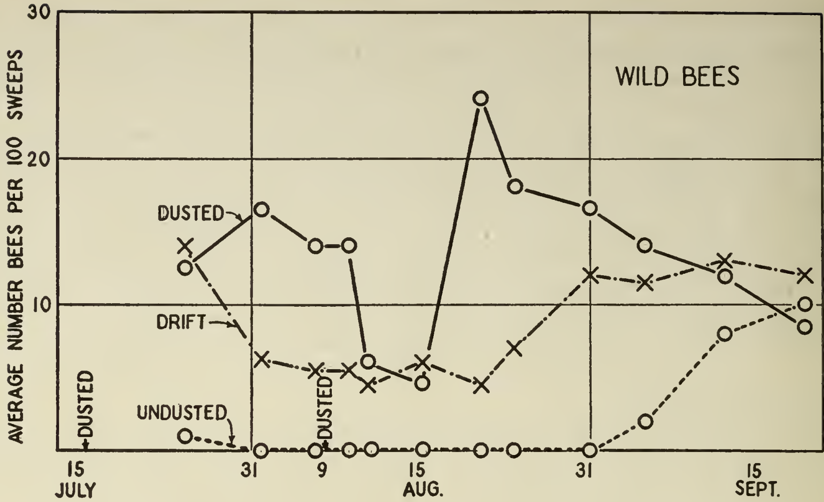
[12] The frame of the net was an ellipse, with a major axis of 15 inches, and a minor axis of 13 inches.

others used in the past are: (1) The results can be readily duplicated by other observers. (2) The bees may be anæsthetized in the net before they are counted, and thus more accurate identifications made possible (questionable specimens may be retained for further study). (3) Counts are possible under unfavorable conditions for visual observation—for instance, when a strong wind is blowing. (4) Counts reveal the presence of species not otherwise noted by the observer, either because of their rapid reaction to the approach of the observer or because they are not conspicuous. (5) It is possible to determine accurately whether or not each captured individual was actually collecting pollen (if necessary, pollen collectors may be retained for pollen analysis). The main disadvantage of the method is that it presumably yields a larger proportion of honeybees than wild bees, but in the present study this would seem to be compensated for by the fact that it provided a uniform method of comparing one field with another.

When the data from all of the fields were analyzed, they exhibited the same characteristic pattern of population trends (figs. 5 and 6). The population in the dusted area dropped markedly on the day following dusting and then gradually built up over a period of 3 or 4 days, frequently reaching a peak higher than it had been when dusted, and usually higher than that in the untreated area. This pattern was evident in the case of 3, 5, and 10 per cent DDT in talc or pyrophyllite, as well as in the case of 4 per cent DDT-fused sulfur.[13] In general, this reduction was not accompanied by recognizable abnormalities in the behavior of the bees remaining in the field, nor were many dead or dying bees noted (this is in marked contrast to sabadilla dust which caused the bees to become "groggy," to buzz around on the ground, and apparently die in large numbers).

As an example of seasonal population trends, the data from a field on Ryer Island are plotted in figure 5. This was a 40-acre field, laid out in an east-west direction. The center section of the field (approximately 12 acres) was dusted, on July 16, with 4 per cent DDT-fused sulfur applied at the rate of 30 pounds to the acre. The prevailing winds are from the west, and the east third of the field was covered by drift from the dusted area (designated in figure 1 as "drift"). No bee counts were taken in the field until July 25. By this date, injury by lygus bugs in the undusted area was beginning to reduce the blossoms to such an extent that the bee population was on a downward trend. This was much less marked in the drift area where there had been partial control of lygus bugs. By early August the total bee population reached a peak, then showed a downward trend, due perhaps partially to increasing injury to blossoms by the bugs. On August 9, the field was again dusted. The dust was applied just before noon on a hot clear day when the field was teeming with bees, at a point in the season when no other alfalfa fields were in bloom on the island and competing pollen plants were reduced to a minimum. Thus, the killing of bees in the field should have had a marked effect upon the bee population, especially that of wild bees, for the remainder of the season. The population fell for about a week, but in 10 days had reached a higher peak than

[13] An attempt to determine whether this same effect would result from the application of talc alone was unfortunately nullified by an unseasonal rain, and no subsequent opportunity arose for repeating the experiment. This point should be investigated further.



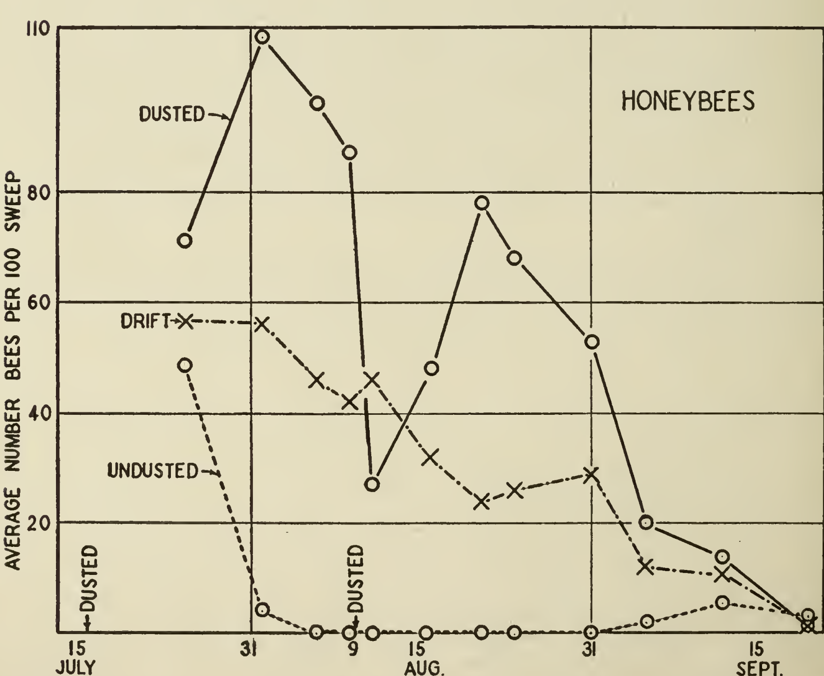


Fig. 5.—Seasonal trend of bee populations in a 40-acre alfalfa field on Ryer Island, California, dusted twice with 4 per cent DDT-fused sulfur at the rate of about 30 pounds to the acre.

on the day of dusting, suggesting the possibility, at least, that the depression in the population did not necessarily reflect bee mortality. Wild bees which are killed cannot be replaced until the following season, and, unlike honeybees, they usually have shorter flight ranges, so nest near the fields from which

they collect pollen. It would therefore seem that the results of these tests might be interpreted to indicate that DDT dusts create an unfavorable condition in the field, causing a large percentage (but not all) of the bees to remain away for a few days, until new blossoms open. The peak which follows is probably due to the greater attractiveness of the field as a result of the increase in blossoms through the control of lygus bugs. However, in view of the possibility that reduced populations reflect bee mortality, further investigation will be required before DDT dusts can be unqualifiedly recommended.

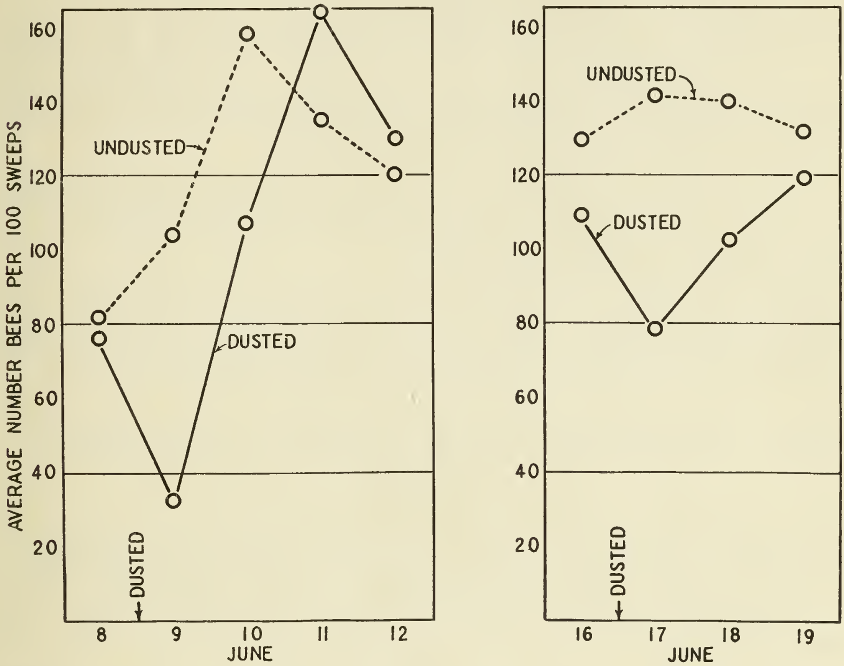


Fig. 6.—Trend of bee population (including both wild bees and honeybees) in the first few days following dusting. Left, a 10-acre field at Blythe, dusted with 5 per cent DDT in pyrophyllite. Right, a 20-acre field at Hemet, dusted with 5 per cent DDT in talc. Both applications at about 30 pounds to the acre.

In the case of fields dusted with DDT in talc or pyrophyllite (fig. 6), the recovery period for the bee population appears to be shorter than in the case of DDT-fused sulfur (fig. 5), although this difference may be a reflection of climatic conditions or of some other factor. Evidence was insufficient to show marked differences between 3, 5, and 10 per cent DDT applications, but some differences may exist. The average recovery period for all three percentages of DDT in talc was 3 to 4 days, and for DDT-fused sulfur, 7 to 10 days. Further studies will be required in order to determine whether or not this apparent difference is real. If so, it may be due to flower injury from sulfur—a result observed in the case of some applications of this material.

The point should be made that, though ultimately it should be proved that DDT dusts kill some of the bees in alfalfa fields, the earlier the dusts are applied in the growth of the seed crop, the lower the bee population is likely

to be; less bloom will be involved, and less likelihood of adverse influence upon either the bees, pollination, or seed set.

Conclusions.—On the basis of studies in four areas of California during the 1945 season, the following tentative conclusions based solely upon observations in alfalfa fields, may be drawn regarding the possible effects of DDT dusts, applied for control of lygus bugs, upon insect pollinators involved in alfalfa seed production:

There was no clear evidence that DDT dusts, applied under the conditions of these experiments, killed any significant number of either wild bees or honeybees. Although about 30 fields were involved in these observations, only a few fields in any one area were dusted simultaneously. It is possible that large-scale simultaneous dusting in an area might have unforeseen consequences, and therefore any unrestricted recommendations for the use of DDT on alfalfa seed crops must await further investigation.

DDT dusts appeared to create for bees a temporarily unfavorable condition which persisted for several days, but ultimately, especially where the populations of lygus bugs were high when the dust was applied, bees were present in greater number than previously.

In order to minimize any possible adverse effect of DDT dusts on bee populations, it is desirable, where control of lygus bugs is necessary, to apply the dusts as early in the growth of the plants as the population of lygus bugs warrants, and to apply a second dusting only when it is clearly required.

EFFECT OF CERTAIN INSECTICIDES ON BEEKEEPING

J. E. ECKERT[14]

There has been much controversy concerning the effect of insecticides on the beekeeping industry. Any injury to the bee colonies also affects indirectly the welfare of those crops that depend upon bees for pollination. Herewith are reported observations on the use of certain insecticides in areas where apiaries are located.

Cryolite.—An attempt was made to indicate the effect of cryolite on colonies of honeybees when applied to corn tassels. Four colonies were placed adjacent to an 80-acre field of popcorn that was to be dusted with a 50 per cent cryolite dust by airplane at the rate of 30 pounds per acre. The colonies were in good condition, normal as to condition and quantity of brood and colony population. They were in place for 10 days before the dust was applied and were gathering pollen from the corn, and nectar and pollen from star thistle and alfalfa in the vicinity.

The morning on which the dust was applied, hundreds of bees were seen in early morning on the ground in front of the hives, crawling away from the entrances, hopping and attempting to fly. By midafternoon, fewer bees were present in front of the hives, most of them having become lost in the stubble where small clumps of bees could be found at distances of 10 to 15 feet. The population of each colony was noticeably reduced.

A sample of the affected bees was taken in the morning and left with the Bureau of Chemistry, State Department of Agriculture, for analysis. The

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bees were tested only for the presence of arsenic instead of fluorine. The analysis showed 12 p.p.m. of arsenic trioxide.

Two samples of pollen were later taken from the combs and analyzed by the same chemist. The samples, respectively, contained 5 and 11 p.p.m., of arsenic trioxide, and 22.6 and 10.5 p.p.m. of fluorine. From these samples it would appear that the bees collected pollen containing both calcium arsenate and cryolite at the same time. The source of the arsenic was not determined and the results, therefore, did not constitute a clear-cut case against cryolite.

The larvae in the brood combs were all killed within a few days, the population of each hive was gradually reduced, and in less than 30 days, all four colonies were dead.

In areas where cryolite is applied to truck crops or to deciduous fruit trees, beekeepers have reported less injury to their colonies than from arsenical applications.

Dinitro Dusts on Citrus.—Several hundred colonies of bees were either killed or seriously injured by the application of DN dusts to citrus trees in Orange County during the past few seasons. Windrows of dead bees were found in apiaries in locations where dinitro compounds were used. In one case where an analysis of dead bees was made, tests for arsenic trioxide and fluorene were negative, but 45 p.p.m. of dinitro cresol was found colorimetrically.

Lead or Calcium Arsenate on Corn.—The application of either lead or calcium arsenate to corn in the attempted control of the corn earworm resulted in killing between 300 and 400 colonies of bees in the Blythe area in the spring of 1945, and left a large number of colonies seriously injured. Since the bees were needed for the pollination of cantaloupes and alfalfa seed, the killing of this number of colonies resulted in reduced pollination services for these crops.

Sabadilla.—Applications of sabadilla dust to alfalfa in the Blythe area resulted in the killing of the bees working on the alfalfa blossoms on the day the dust was applied. After the third day, bees were about as numerous in the field as they were before the application. Unlike the effect of DDT, that of sabadilla killed the honeybees in the field.

DDT and Its Effect on Honeybees.—Observations were made in connection with the application of DDT dusts on various crops influenced by insect pollination to determine the apparent effect on honeybees.

To evaluate the results properly, one must have a sufficient understanding of bee behavior to know the manner in which bees orient themselves in relation to the fields treated; one must also know how DDT affects the honeybee.

The observations of the author have led to the conclusion that when dusts containing 3 or 5 per cent of DDT are applied to alfalfa in bloom, the bees that have oriented themselves to the fields treated may be killed during the first day. As new blossoms open or as the dust is shaken from the blossoms, other bees orient themselves to the treated field and can work with apparent safety on the first or second day after DDT has been applied.

The application of DDT dust to a small acreage of cotton caused no appreciable injury to colonies located in the vicinity, although dead bees were found in the fields treated. Here again, the acreage treated was insufficient to give a true picture of what might be expected if larger acreages are treated simultaneously with DDT.

Where hundreds of acres were dusted with approximately 3 ounces of DDT per acre, in an attempt to control mosquitoes, no appreciable injury to bees in the vicinity was observed.

Bees are stimulated to increased activity by DDT, and some that are exposed recover from the effects if they are given the opportunity to clean their bodies of the dust. When only a relatively small portion of a crop is treated with DDT in an area, it has been found that the total number of bees that visit the treated fields from any given colony or apiary would be insufficient to cause much appreciable injury to any particular colony. Observations have been made which would indicate that colonies have been injured to the extent of two or three frames of bees per colony. Until the treatment is applied to a majority of any particular crop on which the bees are working, no final conclusions can be drawn as to the probable effect DDT might have on colonies of honeybees.

Another factor that would tend to reduce the hazards to beekeeping by the use of DDT is that, at present, the quantity of DDT used per acre is only a small fraction of the amounts of other toxic materials used for the same purpose. For example, when 30 pounds of a 5 per cent DDT dust are applied per acre, only 1.5 pounds of a toxic substance are applied in contrast to 21 pounds of calcium arsenate when a similar quantity of a 70 per cent arsenical dust is applied. The chances are that if only 1.5 pounds of calcium arsenate per acre would prove effective in controlling insects, far less damage would be done to the beekeeping industry and to livestock than is occurring under present conditions.

If the pollinating insects are to be safeguarded from destruction, DDT dust or sprays should be applied before alfalfa, onions, and other crops treated come into bloom. If this is done no appreciable injury can be expected to result to bees from the use of DDT.

Calcium Arsenate.—The experimental apiary of the University of California, at Davis, was again seriously injured in 1945 by calcium arsenate drifting over surrounding territory during its application to tomato fields one mile or more from the apiary. The number of colonies was reduced by the effects of the poison from 75 to less than 20. No honey was produced from star thistle whereas in average years a crop of three tons of honey could be expected. Queen rearing nuclei also suffered destruction and all research work was either destroyed or brought to a stop.

The colonies were first injured early in July. At that time they were united in an attempt to save at least half of them from destruction. In August, the colonies were again injured and several killed. Samples of bees taken from in front of the hives showed as much as 50 p.p.m. of arsenic trioxide. Pollen taken from the combs of stricken colonies contained as much as 26 p.p.m. of arsenic. Pollen in the combs of colonies that survived contained smaller quantities of arsenic, but the amount of arsenic present was sufficient to cause a general reduction of colony strength.

This destruction of the University apiary by the careless application of calcium arsenate to nearby tomato fields is but one example of what has happened to several thousand colonies belonging to commercial or amateur beekeepers in different counties. The dusts have not been applied to most

commercial plantings of tomatoes without causing destructive amounts of the poisons to drift over adjacent property in quantities that are eliminating the beekeeping industry and causing serious loss to livestock, seed, hay, and dairying interests.

It is highly desirable that means of controlling tomato insects other than by the use of calcium arsenate dust be perfected. Further, improvement in the methods of applying the chemicals recommended, so that their application will not constitute a hazard to other agricultural interests, is a problem that needs immediate attention.

Discussion.—The beekeeping industry is an essential part of agriculture in that a majority of the fruit, vegetable, seed, and pasture crops are either dependent on, or are benefited by insect pollination. The increased use of agricultural chemicals, together with weed control and the cultivation of larger areas of land, has tended to reduce the population of native insect pollinators. The beekeeping industry, therefore, produces a large per cent of the pollinating insects needed in a well-balanced agriculture.

In order to maintain colonies economically the beekeeper must produce enough honey to remain in business. Rentals amounting to between one and two dollars per colony per acre are frequently paid by seed and fruit growers to maintain colonies near their fields. However, these rentals will not support the beekeeping industry, and if the colonies are injured or killed by poisons, the beekeeper cannot afford to run the risk of moving his colonies near the crops to be pollinated. It is also necessary for the commercial beekeeper to maintain his colonies in areas where they will produce a maximum quantity of honey. He cannot move "to the hills" or out of cultivated areas in order to avoid having his colonies killed by poisons that are permitted to drift outside the fields treated. It is highly desirable, therefore, for those who recommend poisons and for those who apply them to use chemicals that are least toxic to pollinating insects, and to confine them to the fields treated. When poisons are kept within the confines of the fields treated, then growers and beekeepers together can plan the best possible program for the mutual benefit of all agricultural industries.

LYGUS BUGS ON LIMA BEANS

A. E. MICHELBACHER,[15] RAY F. SMITH,[16] J. W. MACSWAIN[17]
AND A. H. HOLLAND[18]

For a number of years, lygus bugs (*Lygus* spp.) have been known to be injurious to lima beans under certain conditions in California. Investigations to determine the extent of damage were not undertaken by members of the Division of Entomology and Parasitology because no insecticide that could be satisfactorily used to combat this pest on beans was known up to the present time. With the advent of DDT, and encouraging results in its use against lygus bugs on alfalfa, these preliminary studies were started in 1945. In central California the pest was investigated on the baby lima bean, while in Ventura County it was studied on the large lima.

TABLE 2
LYGUS BUG POPULATIONS ENCOUNTERED IN TREATED AND UNTREATED BABY LIMA BEAN FIELDS IN CENTRAL CALIFORNIA

Location	Date dusted	Date surveyed	Average number of lygus bugs per sweep		Stages of growth at time of survey
			Dusted	Undusted	
Westley	July 13	July 16	0.03	0.10	Vines closing rows. Good set of beans
		Aug. 10	1.25	1.26	Fairly good set of beans
Westley	July 13	July 16	0.37	0.30	Bean runners about to close rows
Westley	July 13	July 16	0.25	0.12	Bean runners about to close rows
Ryer Island	....	Aug. 5	....	1.40	Abundance of bloom

Experiments in San Joaquin Valley.—On the northwest side of the San Joaquin Valley, during early July, a heavy drop of crown-set flowers occurred in many baby lima fields. Farmers in the region became very much alarmed and, without any investigation, attributed the drop to injury caused by lygus bugs. These bugs apparently were not numerous enough to be responsible for the damage, but before this fact could be established to the satisfaction of the farmers, they dusted about 700 or 800 acres of beans with DDT. The dust contained 5 per cent DDT, with either talc or pyrophyllite as the carrier, and was applied by airplane. It was used at the rate of between 25 and 30 pounds to the acre. In most cases a portion of a field was left untreated to serve as a check. Most of the fields treated were dusted on July 13. Several of these were surveyed on July 16 and the population of lygus bug was found to be very small. In none of the check areas of the dusted fields surveyed did population exceed 1 bug per sweep. Further, there was no noticeable difference between the population in the treated and untreated portions of the fields. The preliminary information obtained on this and on other surveys is given in table 2, as typical of populations occurring in that area in 1945.

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[16] Instructor of Entomology and Junior Entomologist in the Experiment Station.
[17] Research Assistant in Entomology.
[18] Emergency Assistant in Agricultural Extension.

In a 90-acre baby lima field about 5 miles southeast of Tracy, a population of lygus bugs higher than that found in most fields was encountered. This field had suffered a severe drop of crown flowers. The population of the bugs on July 18 averaged 2.06 individuals per sweep. The grower was anxious to dust the field, so arrangements were made to treat one side of the field with a dust containing 5 per cent DDT in talc, and the other side with a 4 per cent DDT-fused sulfur mixture. Four hundred and fifty pounds of each material

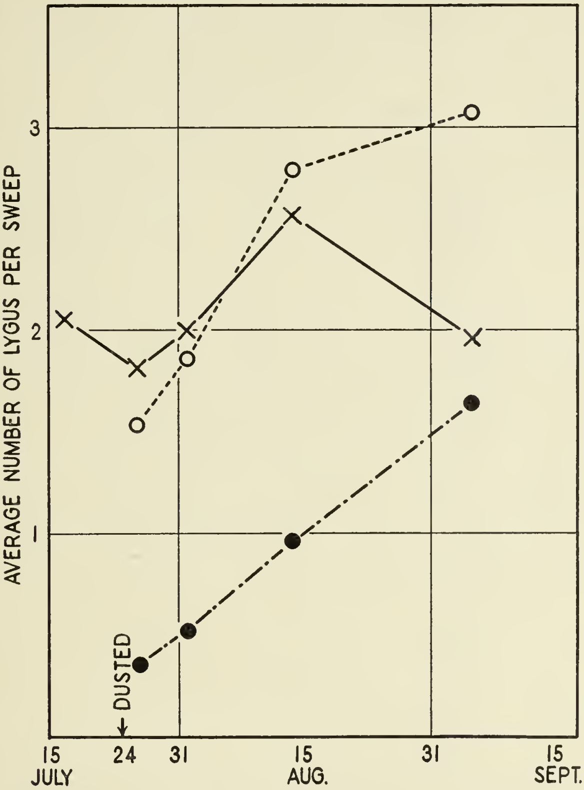

Fig. 7.—Population trend of lygus bugs in treated and untreated portions of a baby lima bean field. Cross, check field; open circle, dusted with 5 per cent DDT in talc; solid circle, dusted with 4 per cent DDT-fused sulfur.

were obtained to apply at the rate of 30 pounds of dust per acre; in this way each test consisted of 15 acres, with the center left as a check. The dusts were applied by airplane, on July 24, under excellent weather conditions. No drift of the insecticide to the untreated center occurred. The application was extremely poor. Not only were the dusts unevenly applied, but instead of 30 pounds to the acre, the DDT talc went on at 20 pounds and the DDT-fused sulfur at 18 pounds per acre. The population trend of lygus bugs during the growth of the crop was observed in the three sections of the field, and is plotted in figure 7. The DDT-fused sulfur gave better control of lygus bugs than did the DDT talc. The latter gave practically no control, but its poor showing may possibly be attributed to inefficient application or the use of a faulty

DDT dust. This assumption was further attested to by the large number of live ladybird and diabrotica beetles found in the field 2 days after dusting. These insects are very susceptible to DDT and would have been nearly wiped out had an effective dust been thoroughly and evenly applied. When harvest records were taken, the section treated with 5 per cent DDT in talc yielded 14.5 sacks of beans per acre, the 4 per cent DDT-fused sulfur yielded 15 sacks,

TABLE 3

POPULATION OF LYGUS BUGS IN TREATED AND UNTREATED LIMA BEAN FIELDS IN VENTURA COUNTY*

Location	Variety of of lima	Date surveyed	Average number of bugs per sweep		Stage of growth
			Dusted	Undusted	
Oxnard 1	Fordhook	July 27	1.78	1.78	Pods and flowers present
		Aug. 1	0.28	2.71	Pods and flowers present
		Aug. 7	0.78	2.50	Pods forming on spikes
		Aug. 14	0.66	2.09	Pods forming on spikes
		Aug. 28	3.64	5.73	Plants not completely mature
Oxnard 2	King of the Garden	Aug. 1	0.54	0.54	Just starting to bloom
		Aug. 7	0.05	0.62	Well into bloom
		Aug. 14	0.08	2.00	Full bloom and pods
		Aug. 28	0.07	0.36	Mature and drying
Oxnard	Ventura	July 18	....	0.92	
		July 27	....	2.95	
Oxnard	Ventura lima	July 27	....	0.62	
Saticoy	Ventura	June 28	....	0.30	
		July 18	....	0.56	
		July 27	....	1.46	
Camarilla	Ventura	June 27	....	0.54	In bloom
		July 18	....	0.27	
		July 27	....	1.63	
Camarilla	Fordhook	June 27	....	0.13	In bloom
		July 18	....	0.43	
		July 27	....	0.80	

* A 4 per cent DDT-fused sulfur dust applied to Oxnard 1 on July 28 and to Oxnard 2 on August 2.

and the check produced 16.5 sacks. According to the grower, the portion of the field treated with DDT-fused sulfur was the poorest yielding section because it had required considerable grading to prepare it for irrigation. From this area, according to the grower, the crop was better than that obtained the previous year—a fact which might mean that some benefit was derived from the control of lygus bugs. However, the field appeared to be somewhat uniform and because the check outyielded either of the treatments, the conclusion may be rather safely reached that the money spent on control was largely wasted.

Experiments in Ventura County.—Several surveys were made in Ventura County. The populations of lygus bugs found on the large lima beans in that area were not greatly different from those encountered on baby limas in central California. Two fields were treated with a 4 per cent DDT-fused sulfur dust, applied with a ground power duster at the rate of 30 pounds per acre. In each

case, portions of the fields were left untreated to serve as checks. The DDT-fused sulfur resulted in excellent control. The results obtained, along with counts of other undusted fields of the Ventura area for comparison, are given in table 3. Yield records were taken and in both cases the treated areas out-yielded the checks. For Oxnard 1, the treated area yielded 24 sacks compared with 20.32 sacks per acre for the check. For Oxnard 2, the treated plot yielded 23 sacks and the untreated 21.06 sacks per acre.

Conclusions.—More extensive investigation is needed before any definite statements can be made concerning lygus-bug injury to lima beans. No doubt exists that, under certain conditions, large and destructive populations occur in the fields. Lygus bugs do migrate in large numbers to beans from alfalfa fields which are cut, or from other favorable host crops when they are harvested. Lygus bugs also find lima beans a suitable crop on which to breed. Despite this danger to beans, there appear to be large acreages where the lygus bugs do not become numerous enough to cause any appreciable damage. The population level at which they become of economic importance remains to be determined.

Where high populations occur, they can be successfully controlled with properly applied DDT dusts. The dusts should contain approximately 5 per cent DDT and should be applied at the rate of 30 pounds per acre. Large-scale use of DDT is not recommended. It should be used with caution until experimental evidence definitely shows that it is not harmful to the various varieties of beans, and that it does not seriously affect the natural balance.

The investigation of DDT has barely started. For the coming year, control involving the use of DDT should be limited to an experimental commercial basis. DDT-sulfur dusts are probably preferable to a DDT-talc mixture, because the sulfur is likely to have a controlling influence upon the mite population.

CONTROL OF CERTAIN COTTON INSECTS WITH DDT AND SABADILLA[19]

GORDON L. SMITH[20]

Experiments on the control of certain cotton insects were continued in 1945 on four plots of cotton at the United States Department of Agriculture Cotton Field Station, Shafter, California. In the experiments at Shafter each plot consisted of 6 rows, 150 feet long, dusted with 3 per cent DDT dust applied with a rotary hand-operated duster.

The first application, with pyrophyllite as a carrier, was made on April 24, when the plants were producing their first leaves and injury from onion thrips was appearing. The treated plots all produced vigorous leaf growth, while in the four untreated plots the leaves were seriously injured by the thrips. No determination was made of the thrips population. A second application, using the same carrier, was made on May 24, but no further, noticeable onion thrips injury occurred on either the treated or untreated plots.

On June 30 another application was made on the same plots for the control of *Lygus hesperus* Knight. At this time the adults averaged 19.2 per 25 tops; no nymphs were present. The carrier used in this application was talc. Twenty-four hours later the adults collected averaged 18.5 per 25 tops on the untreated plots and 11.5 per 25 tops on the treated. This poor initial kill (37.8 per cent reduction), was surprising in view of results obtained in 1944, where 3 per cent DDT in pyrophyllite was used.

In early July there were 11 per cent more blossoms on the plants dusted for the early thrips control than on the undusted ones. This coincides closely with previous work on early thrips control. There were 8 per cent fewer bushy plants in the dusted plots than in the undusted. Therefore, the thrips injury resulting in the killing of terminal buds was reduced by 8 per cent.

A second application for the control of *Lygus hesperus* was made on August 13. This dust was a mechanical mixture of 3 per cent DDT and 70 per cent sulfur, which had produced satisfactory control in another experiment conducted in Fresno County. This treatment gave a reduction from an average of 2 adults and 7 nymphs per 25 tops, to an average of 0.2 adult and 0.5 nymph per 25 tops. The mixture of 3 per cent DDT and talc applied on June 30, which gave only 37.8 per cent kill in 24 hours, may have had a residual value which was more effective than the 24-hour results indicate.

The treated plots yielded at the rate of 1,610 pounds of lint per acre and the remainder of the cotton at the experiment station averaged 1,420 pounds of lint per acre.

In the Fresno County experiments, a 40-acre square field at Kerman was selected and divided into six blocks for the control of *Lygus hesperus*. Three of these plots were used as checks. Three dusts were used: one contained 4 per cent DDT-fused sulfur; the second contained 3 per cent mechanically mixed DDT sulfur; and the third contained sabadilla plus sulfur. The owner had

[19] George J. Harrison, Superintendent of United States Cotton Field Station, Shafter, California, coöperating.

[20] Associate in the Experiment Station.

applied to this area a dust consisting of 7.5 per cent paris green plus 92.5 per cent sulfur on July 5, mostly for the control of red spider, *Tetranychus atlanticus* McG. On July 22, the population of lygus bugs reached a point where control measures should have been taken; however, such measures could not be taken because the field was too wet for a tractor and dusting machine to be pulled through it.

One application only was made of each material on each of the three treated plots on July 29 and 30. Dusting conditions were good, with a slight drift of dust to the southeast. There is some evidence that this drifting caused some reduction in the population of lygus bugs on the control plots to the leeward side.

On July 31, the undusted portions of the field averaged 18.3 adults and 13.2 nymphs per 25 tops. The plot dusted with DDT-fused sulfur (4 per cent DDT and 85.5 per cent sulfur) gave an average of 3.5 adults and 0.2 nymphs per 25 tops, where it was applied at the rate of 15 pounds per acre. This is a reduction of 83.3 per cent. Where the material was applied at 30 pounds per acre, only 1 nymph was collected from 100 tops.

In the plot where a mechanical mixture of 3 per cent DDT and 70 per cent sulfur was applied at 30 pounds per acre, there was an average of 1.5 adults and no nymphs per 25 tops, or a reduction in population of 91.5 per cent. In the plot dusted with sabadilla containing 0.2 per cent alkaloids plus 25 per cent sulfur, there was an average of 2.2 adults and 1.5 nymphs per 25 tops. The adjacent undusted cotton plot had an average of 25 adults and 22 nymphs per 25 tops; therefore, a reduction of 92.1 per cent was obtained.

There was little change in these counts when they were taken again on August 12; DDT-fused sulfur, at 30 pounds per acre, gave 90 per cent fewer bugs than in the untreated adjacent check; DDT-sulfur mixture, 66 per cent fewer; and sabadilla, 83 per cent fewer. On August 31 the DDT-fused sulfur block had dropped to 57.4 per cent fewer; DDT-sulfur mixture, 67 per cent fewer; and sabadilla, only 8 per cent fewer lygus bugs than in the adjacent untreated plots.

In late July, a few spots of red spider infested plants existed in the undusted portions of the field, but none where sulfur was applied. There was not enough difference in plots to indicate the amount of sulfur which may be necessary for the control of red spiders on cotton.

The percentage increases in the yields of seed cotton from these plots, when compared with adjacent check plots and with the average of all untreated areas, were as follows:[21]

	Percentage increase over adjacent untreated areas	Percentage increase over average of all untreated areas
DDT-fused sulfur	11.6	10.04
DDT sulfur	17.1	11.00
Sabadilla plus sulfur	11.6	14.83

A summary of the lygus bug populations, along with the yield of seed cotton from the treated and untreated portions of the field, are given in table 4.

The great majority of the cotton bolls which constitute the harvested crop in the San Joaquin Valley form on the plants between about July 1 and

[21] Data obtained by E. E. Saunders, Assistant Farm Advisor, Fresno County.

TABLE 4

AVERAGE NUMBER OF *Lygus hesperus* PER TWENTY-FIVE TOPS OF COTTON TREATED WITH SEVERAL INSECTICIDES, AT KERMAN*

Treatment	Number of rows	Dates of lygus bug counts before and after treatment												Seed cotton, pounds per acre
		July 28			July 31			August 12			August 31			
		Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	Adults	Nymphs	Total	
Untreated	36	17.8	5.5	23.3	20.3	9.8	30.1	14.0	31.3	45.3	11.3	24.5	35.8	2,140
DDT-fused sulfur†	8	21.3	12.5	33.8	3.5	0.3	3.8	3.8	2.8	6.6	....	....	....	....
DDT-fused sulfur‡	68	21.3	12.5	33.8	0.3	0.3	0.6	2.0	0.0	2.0	3.7	13.5	17.2	2,300
Untreated	68	14.8	9.3	24.1	10.3	7.8	18.1	10.5	7.5	18.0	8.5	31.3	39.8	1,980
DDT sulfur‡	100	17.5	9.5	27.0	1.5	0.0	1.5	4.1	2.4	6.5	3.8	8.8	12.6	2,320
Sabadilla plus sulfur‡	80	37.5	32.5	70.0	2.3	1.5	3.8	5.0	4.0	9.0	14.0	33.8	47.8	2,400
Untreated	25	41.0	24.0	65.0	25.0	22.0	47.0	15.8	37.5	53.3	14.3	37.6	51.9	2,150

* The arrangement of the table is based on the field plot layout; the rows ran east and west, and the plots were in the order shown, north to south, beginning with the 36 untreated rows. The populations may have been slightly reduced in the untreated plots by drift of the insecticides to the southeast.

† Applied at rate of 15 pounds per acre.

‡ Applied at rate of 30 pounds per acre.

August 15. It is therefore very important to protect the bolls during this period to produce the maximum amount of highest quality fiber.

Both workers in cotton research and some growers have expressed the belief that even though some DDT and sabadilla applications were made as late as August 13, an improvement resulted in the quality of the fiber in late bolls. If this proves constant, then the improved quality without an increased yield may make the control of lygus bugs even in late August a profitable practice.

CONTROL OF DARKLING GROUND BEETLES ON TOMATOES[22]

B. J. KONKRIGHT[23] AND W. H. LANGE, JR.[24]

Small darkling ground beetles, particularly *Blapstinus* spp. and *Metoponium abnorme* (Lec.), often damage tomato transplants by feeding on the stems at the ground level. The tests reported here were initiated at the request of tomato growers in the Woodland area to determine the relative efficacy of dusts and baits for the protection of tomato transplants. Usually damage is most serious during the first few days after the plants are set out. The degree of damage may be minor or may result in complete girdling of the stems. When extensive or complete girdling occurs, the plants are killed outright or are so weakened that any physical contact or wind can cause them to break off completely or to fall to one side.

In the present experiments, three tests were conducted in three different fields in the Woodland area. It was decided to use proprietary baits because the growers in most instances were not equipped to make their own. The baits and dusts used are given in table 5. The different treatments were applied to plots of 50 tomato plants, each treated plot alternating with an untreated plot of 50 plants, located in areas where beetle damage was suspected. Each material was replicated three times. This arrangement was later found to be satisfactory in cases where beetles caused injury. Of the three areas tested, only one proved to have beetles in sufficient numbers to cause damage great enough to show differences. The dusts (0.75 pound of dust to 50 plants), were applied to the ground and bases of the plants by means of a hand duster. The baits (1 pound of bait to 50 plants), were applied in a ring around the base of each plant.

On May 7, 1945, baits were put out in the late afternoon on a field at Woodland infested with *Blapstinus* spp. The results of the trials are summarized in table 5, which shows the per cent of dead or injured plants observed on several days. The baits were not applied until the second day of planting and so a small amount of injury occurred before they were applied. From these tests it is obvious that the hydrated lime and 3 per cent DDT were very effective in protecting the plants, but that calcium arsenate dust and the baits offered very little or no protection. The DDT dust gave a slightly better control than

[22] The authors acknowledge the assistance of F. Du Bois and H. Fryer in conducting these experiments.

[23] Assistant in Agricultural Extension.

[24] Assistant Entomologist in the Experiment Station.

TABLE 5

Results Obtained at Woodland with Baits and Dusts Applied on May 7, 1945, for the Protection of Tomato Transplants from Injury by the Small Darkling Ground Beetle

Material	Per cent of plants dead or injured by beetles			Per cent of plants dead or injured from other causes		
	May 12	May 16	May 27	May 12	May 16	May 27
Untreated check*	25	31	32	6	7	8
Baits						
Calcium arsenate, 5.16 per cent†	26	36	38	2	2	2
Sodium fluosilicate, 4.75 per cent	8	18	26	6	12	12
Sodium fluosilicate, 5.0 per cent	12	22	26	6	6	6
Tricalcium arsenate, 5.0 per cent	14	24	28	2	6	6
Cupric acetoarsenite, 3.2 per cent	16	22	24	6	6	6
Dusts						
DDT, 3 per cent, in talc	2	2	6	2	4	8
Hydrated lime, 100 per cent	4	8	8	2	2	4
Calcium arsenate (undiluted)	20	32	32	8	10	12

* Average of 7 untreated blocks of 50 plants each.
† Bait in the form of pellets.

the hydrated lime. It is suspected that the protection afforded by these materials is due to a repellent action.

Injury to tomato plants by DDT has been reported by other investigators; therefore until such time as the full physiological and other effects of DDT on tomato plants can be fully studied, the use of hydrated lime is recommended. Since lime causes some burn to tomatoes under certain conditions, caution should be taken not to dust the plants too heavily.

These results should be interpreted as being of a preliminary nature. Before final recommendations are in order, further work should be conducted in testing various dust combinations for the protection of tomato transplants from darkling ground beetles.

CONTROLLING THRIPS AND TOMATO SPOTTED WILT WITH DDT[25]

M. W. GARDNER[26] AND A. E. MICHELBACHER[27]

Spotted wilt, a serious disease of tomatoes, is transmitted by thrips. In 1944,[28] studies were undertaken with DDT for controlling thrips and indirectly spotted wilt, in the fall-winter crop of tomatoes grown in a greenhouse. A DDT water suspension spray was compared with a nicotine-fumigation program, which had proved successful in reducing the thrips population to a level where spotted wilt infection was no longer a limiting factor in the production of tomatoes. Frequent fumigation is necessary to combat the constant influx of infective thrips from out of doors. The DDT was used at the rate of

Fig. 8.—Injury to tomato leaflets caused by spraying with DDT, 1 pound per 100 gallons. *A,* Normal leaflet. *B, C,* Sprayed leaflets showing interveinal and marginal yellowing. *D,* Sprayed leaflet in final stages of injury, showing tan-colored, papery drying out of the marginal tissues.

1 pound of actual DDT to 100 gallons of water. Four spray applications were made between the time the plants were set in the greenhouse and the time the fruit reached the size of marbles. This program resulted in better control of thrips and spotted wilt than was accomplished by the nicotine-fumigation schedule. However, the DDT treatment in the 1944 season resulted in serious injury to the tomato plants (fig. 8) which markedly reduced the yield.

Experiments in 1945.—Although thrips and spotted wilt are a serious problem only in the fall-winter crop, DDT sprays were applied to the 1945 spring crop in order to determine whether injury to the tomato plants could be avoided by reducing the concentration of DDT in the spray. The amount

[25] This investigation was made possible through the wholehearted coöperation of Mr. and Mrs. Francis Aebi of the Aebi Nurseries, Richmond, California.

[26] Professor of Plant Pathology and Plant Pathologist in the Experiment Station.

[27] Assistant Professor of Entomology and Assistant Entomologist in the Experiment Station.

[28] California Agricultural Experiment Station. Investigations with DDT in California, 1944. (A preliminary report prepared under the direction of the Division of Entomology and Parasitology.) (Lithoprinted.) 33 p. March, 1945.

of actual DDT per 100 gallons of water was lowered from 1 to 0.6 pound. The spray was applied at a pressure of approximately 300 pounds, and treatment was started when the plants were 8 to 10 inches tall. The first spray was applied on February 20, to 32 plants. Subsequent applications were made March 6, March 20, and April 4. With each succeeding application, 12 additional plants were treated, so that following the last application, on April 4, some plants had received one to four sprays. None of these treatments produced

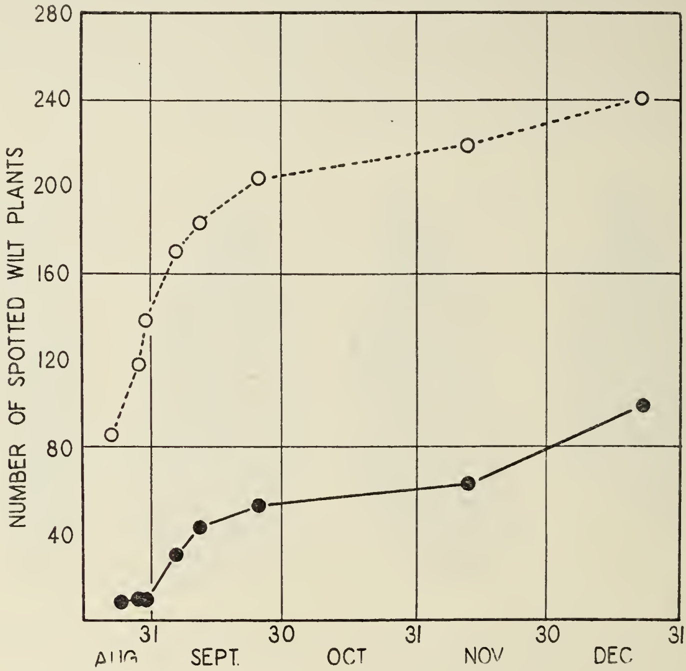

Fig. 9.—Accumulated number of tomato plants infected with spotted wilt in each of two greenhouses, one sprayed with DDT (solid circles), the other fumigated with nicotine (open circles), to control thrips, the vectors of the virus. During August and September the spotted wilt plants were removed. Marked reduction of early infection was obtained with the DDT.

any apparent injury, so it was decided to use a 0.6-pound dosage of DDT in an attempt to control thrips on the following fall-winter crop of tomatoes.

On July 28, 1945, the day before the tomatoes were planted in the greenhouse, the inside and outside of the house were sprayed with 50 gallons of a 20 per cent DDT wettable powder, used at the rate of 5 pounds to 100 gallons of water. The house was planted, using a total of 781 plants. On August 22, the plants were lightly sprayed with 25 gallons of a spray containing 0.6 pound of actual DDT (3 pounds of 20 per cent DDT wettable powder) to 100 gallons of water, applied at a pressure of 250 pounds. A similar treatment was applied on August 29, and again on September 5. Further treatment with DDT was discontinued in order to avoid a residue problem. On September 19, the house was fumigated with nicotine, and this treatment was repeated once a week thereafter until November 1.

This house was compared with a similar greenhouse where thrips were

controlled entirely by fumigation with nicotine. This house was planted to tomatoes on August 3, and was fumigated twice a week until September 25, and once a week thereafter until November 1.

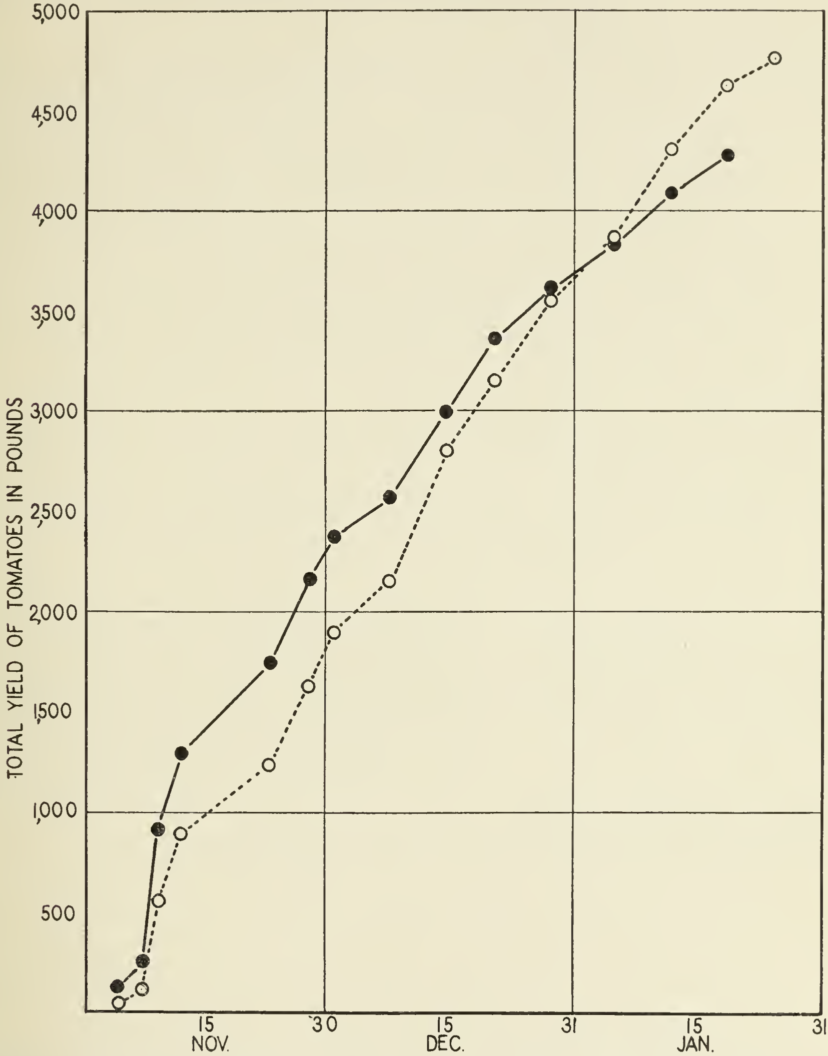

Fig. 10.—Accumulated yields of tomatoes in a greenhouse sprayed with DDT (solid circles) and in a greenhouse fumigated with nicotine (open circles) to control thrips, the vectors of the spotted wilt virus. Despite better disease control, as shown in figure 9, the final yield of the sprayed house was somewhat lower, possibly because of mild DDT injury to the plants.

In each house, the spotted wilt plants were removed during August and September and the numbers recorded. This information, along with two later disease counts, is plotted in figure 9. Many less plants (total 98) were infected with spotted wilt in the house sprayed with DDT than in the house fumigated with nicotine (total 241). This fact substantiates the results obtained in

1944 with respect to control. Infection was most prevalent in August and September. The first three disease counts indicate that the preliminary spray of strong DDT, applied to the empty house, was important in reducing infection. After the use of DDT was discontinued, the rates of infection in the two houses were not very different.

Despite the reduced strength of the spray, which had proved safe on the spring crop, the DDT sprays applied to the plants caused some injury—more apparent on some plants than on others—and, in general, not appearing until some time after all the applications were made. By November 12, about 143 plants showed injury in the form of a gradually increasing yellowing and tan necrosis of the basal leaves up to about 30 inches from the ground, the approximate height of the plants when the last spray was applied. Since the injured plants tended to occur in groups, uneven application of the sprays was indicated. The yield records at each picking are plotted in figure 10. At first the sprayed house outyielded the fumigated house, but the total yield of the sprayed house (4,287 pounds) was 10 per cent less than that of the check (4,762 pounds).

In a field test near Concord,[29] three spray applications of DDT (0.6 pound per 100 gallons) were made in a plot of 767 tomato plants with a power sprayer on June 26, July 14, and July 28, 1945. No injury to the plants was apparent. Fifteen per cent of the plants in the sprayed plot became infected with spotted wilt, as compared with 21 per cent in the unsprayed check plot of 537 plants.

Summary.—Spraying with DDT proved more effective than nicotine fumigation in the control of thrips and spotted wilt in greenhouse tomatoes. An application to the empty house, just prior to planting, appeared to be especially effective. The three DDT applications to the plants caused some injury, even though the spray material was very lightly applied and was used at the rate of only 0.6 pound per 100 gallons. Spraying with DDT in the field crop of tomatoes for the control of thrips and spotted wilt showed some promise and caused no injury to plants.

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[29] The coöperation of Mr. B. H. Gelbke is gratefully acknowledged.

TESTS WITH DDT AND OTHER MATERIALS FOR THE CONTROL OF ONION THRIPS ON ONIONS IN THE SALINAS VALLEY[30]

W. H. LANGE, JR.[31]

During 1944, preliminary tests in the San Joaquin River delta and Salinas Valley[32] indicated that DDT both in the form of dusts and of oil emulsions gave satisfactory control of onion thrips on onions. The tests reported here present additional information concerning the use of DDT and other materials.

The first series of experiments were conducted near Soledad on Australian Brown onions. Dusts, sprays, and vapo-spray materials were applied to the onions from June 11 to June 13. The onions were half grown at the time of application; and the field was then heavily infested with onion thrips and showed some injury. The spray materials used and rates per 100 gallons of water, the composition of the vapo-sprays and dust mixtures are given in table 6. The spray materials were applied by means of a power sprayer at from 125 to 150 pounds pressure, and 180 gallons per acre, using two Monarch No. 90 weed spray nozzles to each double row. The vapo-spray materials were applied by means of a vapo-spray machine using 5 to 7 gallons of material per acre. The dusts were applied by a power duster using two discharge nozzles to a double row of plants at from 30 to 35 pounds per acre.

The experiments consisted of a total of 24 plots. The treated plots were from 6 to 12 double rows wide and 1,385 feet long. All but one treated plot were 12 double rows wide, or about seven-tenths acre in extent. Each treated plot was flanked by an untreated plot on either side, usually 8 double rows wide. The DDT wettable powder and DDT oil emulsion (20 per cent DDT) were applied on June 11, the dusts and vapo-sprays on June 12, and the DDT oil emulsion (4.85 per cent DDT) on June 13.

On June 13, from each plot 15 onions were collected and brought back to the laboratory for population determinations. A washing and filtering method was used to count the number of thrips. The counts of June 13 indicated that the 20 per cent DDT-oil emulsion gave the best reduction in nymphs. This was followed in order of their efficiency by 5 per cent trichloro-chloro-phenyl-phenyl-ethane dust; 4 per cent DDT-sulfur dust; DDT-oil emulsion (4.85 per cent DDT); and 5 per cent DDT dust. The other treatments were wholly ineffective under the conditions of this experiment. Fifteen to 17 days following the application, on June 28, the nymphal populations of the checks averaged 841 per plant, and some treatments reached as high as 1,544 nymphs per plant. On June 28 the best control was indicated in the plot treated with 4 per cent DDT-fused sulfur dust, followed by the 2.4 per cent DDT vapo-

[30] The author acknowledges the assistance of E. M. Stafford in making the population counts presented herein. Appreciation is due W. Buchser, L. Gardner, A. Himmah, L. L. Isenhour, Paul Jones, B. J. Konkright, W. Nielsen, and W. A. Simanton for supplying materials or for assistance in the field.

[31] Assistant Entomologist in the Experiment Station.

[32] California Agricultural Experiment Station. Investigations with DDT in California, 1944. (A preliminary report prepared under the direction of the Division of Entomology and Parasitology.) (Lithoprinted.) 33 p. March, 1945.

TABLE 6

RESULTS OF TESTS WITH SEVERAL INSECTICIDES FOR CONTROLLING THE ONION THRIPS ON AUSTRALIAN BROWN ONIONS AT SOLEDAD

(Applications made on June 11 to 13, 1945)

Materials	Number of thrips per plant, June 13		Per cent control, June 13		Number of thrips per plant, June 28		Per cent control, June 28	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
Sprays								
DDT wettable powder (20 per cent DDT), 5 pounds; water, 100 gallons	274.6	67.4	13.5	0.0	1,544.4	131.1	0.0	0.0
DDT wettable powder (20 per cent DDT), 5 pounds; wetting agent, 600 cc*; water, 100 gallons.	273.5	49.8	13.9	0.0	1,171.0	77.4	0.0	24.8
DDT-oil emulsion (4.85 per cent DDT), 1.5 gallons; water, 100 gallons	218.4	5.2	31.2	76.6	536.6	97.8	36.2	5.0
DDT-oil emulsion (20 per cent DDT), 1 gallon†; water, 100 gallons	9.6	5.2	97.0	76.6	455.5	88.4	45.9	14.1
Vapo-sprays								
DDT, 1.2 per cent in a vapo-spray oil‡	403.5	12.8	0.0	42.3	633.6	82.0	24.7	20.3
DDT, 2.4 per cent in a vapo-spray oil	470.0	14.9	0.0	32.9	434.7	100.9	48.3	1.9
DDT, 2.4 per cent; cardolite, 7.5 per cent; derris resins, 0.65 per cent; rotenone, 0.25 per cent	269.4	28.4	15.1	0.0	1,395.7	253.8	0.0	0.0
Dusts								
DDT, 3 per cent; inert, 97per cent.	595.9	9.4	0.0	57.7	715.5	79.0	15.0	23.2
DDT, 4 per cent; sulfur, 85.8 per cent; inert,10.2 per cent	139.4	5.2	56.1	76.6	117.8	76.9	86.0	25.3
DDT, 5 per cent; inert, 95 per cent.	229.8	9.4	27.6	57.7	607.9	116.2	27.7	0.0
Trichloro-chloro-phenyl-phenyl-ethane (Tanatox), 5 per cent; inert, 95 per cent	42.3	10.3	86.7	53.6	464.7	57.3	34.8	44.3
Checks, untreated§	317.5	22.2	.....	.....	841.3	102.9	.....	.....

* A 10 per cent solution of dioctyl ester of sodium sulfosuccinate.
† Gesarol oil emulsion supplied by the Geigy Company of New York.
‡ Specification of oil: 70 per cent mineral seal oil of 45 to 50 viscosity (90 U.R.) and 30 per cent kerosene.
§ Average of 4 untreated plots on June 13; 12 untreated plots on June 28.

spray, the two DDT-oil emulsions and the trichloro-chloro-phenyl-phenyl-ethane dust. The high populations of thrips and the amount of damage in the plots made further applications seem of little avail. Observations in the field on June 28 and later in the season indicated that the only treatment showing a residual effect on control was the 4 per cent DDT-fused sulfur dust. The onions in this plot showed less injury and were green and erect after the other plants had dried up because of severe thrips injury. The results of this experiment are summarized in table 6.

On June 13 a series of small-scale hand-dusted plots was established in the same field where the previous experiment was conducted. A 3 per cent DDT dust was compared with a 10 and 20 per cent sabadilla dust and a 5 per cent phthalonitrile dust. The results of these tests are summarized in table 7. On June 28, when population counts were made, the DDT dust was found to be superior to sabadilla and phthalonitrile.

A second extensive series of tests were conducted at Salinas on Southport White Globe onions grown for dehydration. Two applications were made, the first on June 26–27, and the second on July 14. The first application was made when the onions had six leaves and were approximately one-quarter grown.

TABLE 7

RESULTS OF EXPERIMENTS WITH SEVERAL DUST MIXTURES FOR CONTROLLING ONION THRIPS ON AUSTRALIAN BROWN ONIONS AT SOLEDAD

(Application made with hand rotary duster on June 13, 1945)

Dusts and amounts used per acre	Number of thrips per plant, June 28		Per cent control, June 28	
	Nymphs	Adults	Nymphs	Adults
DDT, 3 per cent; inert, 97 per cent; at 33 pounds	239.3	110.5	62.2	0.0
Sabadilla, 10 per cent; inert, 90 per cent; at 33 pounds	422.2	88.4	33.3	17.2
Sabadilla, 20 per cent; inert 80 per cent; at 66 pounds	407.4	89.0	35.7	16.7
Phthalonitrile, 5 per cent; frianite, 85 per cent; diatomaceous earth, 10 per cent; at 41 pounds	644.3	119.7	0.0	0.0
Check, untreated	633.3	106.8	....	....

The spray applications were made with a Bean power sprayer at 100 pounds' pressure, with three Monarch No. 54 weed nozzles to a double row of onions, and 200 gallons of spray per acre. The dusts were applied with a power duster, using 35 to 45 pounds of dust per acre for each application. The plots were strips one-quarter to one acre in extent and varied from 4 beds (double rows) in width to 16 beds in width.

The composition of the sprays and dusts and the results of this series of experiments are presented in table 8. At the time of the first population count on July 10, the DDT-soluble oil emulsion (1.5 gallons of a mixture containing 4.85 per cent DDT)[33] gave an outstanding kill of nymphs, but on July 20, 6 days after the second application, the control had fallen considerably. The DDT oil emulsion[34] gave the most consistent control during these tests, which averaged over 80 per cent. The DDD spray gave a consistent 70 per cent reduction in nymphs. The DDT wettable powder gave good control with colloidal depositor, but poor control with 0.75 per cent of a soluble oil. The 3 per cent dusts gave 80 per cent reductions on July 10, but fell considerably by July 20. The 5 per cent DDT dust was apparently faulty and did not give as good control as the 3 per cent dusts. It was apparent that the sabadilla dust, the beta beta′ dithiocyano-diethyl ether sprays and dusts, and the 2 per cent DDT with sulfur dust were not satisfactory in this particular series of tests.

On July 12, 1945, a series of dusts was applied at Salinas to Southport

[33] See table 8 for the complete formula of this emulsion.

[34] See table 8 for the complete formula of this emulsion.

TABLE 8

Comparative Tests of Several Insecticides for Controlling Onion Thrips on Southport White Globe Onions at Salinas

(First application on June 26; second on July 14, 1945)

Material	Number of thrips per plant, July 10		Per cent control, July 10		Number of thrips per plant, July 20		Per cent control, July 20	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
Sprays								
DDT 20 per cent wettable powder, 5 pounds; DDT colloidal depositor, 1 pound; water, 100 gallons..	28.8	3.5	80.2	86.5	39.0	16.7	43.4	37.2
DDT 20 per cent wettable powder, 5 pounds; light soluble summer oil, 0.75 gallon; water, 100 gallons	67.7	20.6	53.4	20.5	26.5	2.3	61.5	91.4
DDT 4.85 per cent in extra light soluble summer oil, 0.75 gallon; water, 100 gallons...............	142.9	24.7	1.7	4.6	63.8	18.7	7.4	29.7
DDT 4.85 per cent in extra light soluble summer oil, 1.5 gallons; water, 100 gallons...............	8.6	1.6	94.1	93.8	35.1	13.9	49.1	47.7
Dichlorodiphenyl-dichloroethane (DDD) oil emulsion, 1 gallon;* water, 50 gallons................	41.7	6.2	71.3	76.1	20.3	6.2	70.5	72.9
DDT-oil emulsion, 1 gallon†; water, 50 gallons................	28.1	8.6	80.7	62.9	9.3	2.3	86.5	91.4
Beta beta′ dithiocyano-diethyl ether 13.5 per cent (with 86.5 per cent inert), 2.5 pounds; phthalic glycerol alkyl resin spreader, 0.25 pint; water, 50 gallons......	158.6	20.3	0.0	21.6	75.6	22.7	0.0	14.3
Beta beta′ dithiocyano-diethyl ether (20 per cent), 1 pint; water, 100 gallons......................	184.3	22.6	0.0	12.7	104.4	20.3	0.0	23.7
Dusts								
DDT, 3 per cent; inert, 97 per cent.	31.9	10.2	78.0	60.6	33.5	10.1	51.4	62.0
DDT, 3 per cent; inert, 97 per cent.	27.7	12.4	80.9	52.1	52.2	8.6	24.2	67.7
DDT, 2 per cent; sulfur, 89.7 per cent; inert, 8.3 per cent.........	72.2	27.7	50.3	0.0	208.8	27.9	0.0	0.0
DDT, 5 per cent; inert, 95 per cent.	45.3	14.4	68.8	44.0	111.0	110.2	0.0	0.0
Dichlorodiphenyl-dichloroethane (DDD), 5 per cent; inert 95 per cent............................	105.6	20.9	27.3	19.3	40.5	13.3	41.2	50.0
Sabadilla, 20 per cent; soapstone, 35 per cent; magnesium carbonate, 5 per cent; hydrated lime, 40 per cent............................	105.2	16.3	27.6	44.7	81.4	34.7	0.0	0.0
Check, untreated‡...............	145.3	25.9	....	....	68.9	26.6	....	....

* A stock emulsion containing 0.5 pound 1,1-bis (*p*-chlorophenyl)-2,2-dichloroethane, 1 pint benzene, 4 pints kerosene, 28 grams of a phthalic glycerol alkyl resin, light medium soluble summer oil to make 1 gallon.

† A stock emulsion containing 0.5 pound technical DDT, 1 pint benzene, 4 pints kerosene, 28 grams of a phthalic glycerol alkyl resin, and light medium soluble summer oil to make 1 gallon.

‡ Average of 6 untreated plots.

White Globe onions to test the relative value of DDT-fused sulfur mixtures compared with mechanically prepared DDT-sulfur mixtures, a 10 per cent DDT dust with a clay carrier, and a beta beta′ dithiocyano-diethyl ether dust. The dusts were applied by means of a power duster to strip plots 1,200 feet long by 8 to 15 double rows wide. Population determinations were made by examining 10 plants from each plot on July 14, July 20, and August 4. The dusts were applied at 35 to 40 pounds per acre, and single applications were made. The onions were 75 per cent mature at the time of application. The composition of the dusts and results of these tests are shown in table 9. It was apparent from these tests that 10 per cent DDT in a clay carrier was superior to the other mixtures during the period up to July 20, but by August 4 this difference could no longer be detected. Little difference was noted between the 4 per cent DDT-fused sulfur mixture compared with the mechanically mixed DDT-sulfur dusts. The 4 per cent DDT mechanically mixed with 90 per cent sulfur was difficult to handle in the duster, and this probably accounts for the poor initial control.

The beta beta′ dithiocyano-diethyl ether dust gave a good kill of nymphs when examined 48 hours following treatment, but effected no permanent control.

As a result of the previous tests in which sulfur combined with DDT was superior to DDT at comparable strengths with other carriers, a series of tests were conducted at Salinas to determine the amount of sulfur necessary to give best results. Dusts were applied by means of a rotary hand duster on August 22. Two series of dusts were tested; one series contained 3 per cent DDT and the other 5 per cent DDT with sulfur contents of 25, 50, and 75 per cent. The dusts were applied to plots one-fortieth acre in size and the population was determined by examining 10 onions from each plot on August 23. The results are summarized in table 10. It would appear from these results that at the 3 per cent DDT level the efficiency of the dust in killing nymphs increased as the sulfur content was increased. The same trend was obtained with 5 per cent DDT, although it was apparent that the concentration of DDT and the amount of dust used per acre are also important. From these tests it would appear that a sulfur content of 75 per cent greatly increases the efficiency of the DDT dust. The use of greater amounts of sulfur might interfere with the physical dusting properties of the dust and be undesirable.

Discussion of Results.—From the results of experiments conducted in the Salinas Valley during 1945 it is apparent that certain spray and certain dust combinations containing DDT are of value in controlling the onion thrips. Of the spray combinations, the DDT-oil emulsions gave the best reductions in nymph populations, with the wettable powders alone or with oils or additional spreaders not as satisfactory. Of the dust mixtures it was found that DDT combined with 75 per cent dusting sulfur either as a fused or mechanically mixed product was superior to DDT with other inert carriers. The fluctuation in adult populations in the field would indicate that in these tests more emphasis should be placed on nymphal populations as an index of control. These tests would indicate that under conditions of high population levels it is difficult to reduce nymph populations by means of a single treatment, but that two or three applications may be necessary to obtain good

TABLE 9

APPLICATION OF DUST MATERIALS FOR CONTROLLING ONION THRIPS ON SOUTHPORT WHITE GLOBE ONIONS AT SALINAS

(Applied with power duster on July 12, 1945)

Dusts applied	Number of thrips per plant						Per cent control					
	July 14		July 20		August 14		July 14		July 20		August 14	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
DDT, 4 per cent*; sulfur, 50 per cent; neutral clay, 42 per cent; other inert, 4 per cent	57.9	2.9	28.1	17.5	21.0	0.0	48.9	85.0	70.9	58.6	82.2	100.0
DDT, 4 per cent*; sulfur, 90 per cent; neutral clay, 2 per cent; other inert, 4 per cent	104.0	10.5	30.4	3.5	29.2	0.0	8.3	45.6	68.5	91.7	75.3	100.0
DDT, 10 per cent*; neutral clay 90 per cent	22.1	4.1	11.7	7.0	28.1	1.2	80.5	78.8	87.9	83.5	76.2	47.8
DDT, 4 per cent†; sulfur, 85.8 per cent; inert, 10.2 per cent	19.9	8.2	58.4	15.2	31.6	0.0	83.3	57.5	39.5	64.1	73.2	100.0
DDT, 4 per cent*; sulfur, 50 per cent; inert 46 per cent	19.3	3.5	30.4	37.4	24.5	0.0	83.0	81.9	68.5	11.6	79.2	100.0
Beta beta′ dithiocyano-diethyl ether, 2.5 per cent; inert, 97.5 per cent	33.9	10.5	85.3	49.7	....		70.1	45.6	11.7	0.0	....	....
Check, untreated‡	113.4	19.3	96.6	42.3	118.0	2.3	.	...	....	....	....	....

* DDT mechanically mixed with the diluents using a 50 per cent DDT concentrate.
† DDT intimately fused with sulfur.
‡ Average of three untreated areas.

TABLE 10

RESULTS OF TESTS WITH DDT AND SULFUR DUSTS FOR CONTROLLING ONION THRIPS ON SOUTHPORT WHITE GLOBE ONIONS AT SALINAS

(Applied with hand duster on August 22, 1945)

Dusts and amounts used per acre	Number of thrips per plant, August 23		Per cent control, August 23	
	Nymphs	Adults	Nymphs	Adults
DDT, 3 per cent; sulfur 25 per cent; diatomaceous earth, 10 per cent; talc, 62 per cent; 41 pounds	11.7	1.7	50.0	80.7
DDT, 3 per cent; sulfur, 50 per cent; diatomaceous earth, 10 per cent; talc, 37 per cent; 41 pounds	7.6	1.8	67.5	79.5
DDT, 3 per cent; sulfur, 75 per cent; diatomaceous earth, 10 per cent; talc, 12 per cent; 41 pounds	3.5	0.0	80.8	100.0
DDT, 5 per cent; sulfur, 25 per cent; diatomaceous earth, 10 per cent; talc, 60 per cent; 41 pounds	4.7	1.8	75.6	79.5
DDT, 5 per cent; sulfur, 50 per cent; diatomaceous earth, 10 per cent; talc, 35 per cent; 31 pounds	5.8	0.0	75.2	100.0
DDT, 5 per cent; sulfur, 75 per cent; diatomaceous earth, 10 per cent; talc, 10 per cent; 41 pounds	2.3	0.0	90.2	100.0
Check, untreated	23.4	8.8	....	....

control. The applications at Soledad were applied under rather adverse conditions; high temperatures and strong winds occurred following the treatments. The applications at Salinas occurred under rather humid conditions, with considerable fog or overcast weather following the treatments. The vapo-spray treatments did not show to advantage in these tests. This was thought to be due to the fact that the materials could not be forced far enough down into the bases of the leaves. A new chemical, dichlorodiphenyl-dichloroethane (DDD) was found to show promise for onion thrips control both in dusts or sprays, but further work is necessary to determine the relative value of this chemical as compared with DDT.

OBSERVATIONS ON THE COMMERCIAL CONTROL OF ONION THRIPS ON ONIONS

A. D. BORDEN[35]

This particular field investigation in the control of the onion thrips was not of the usual experimental type, but was an extensive commercial demonstration of the effectiveness of DDT against this serious onion pest. All applications were made by the growers' men and equipment under general direction.

The planting consisted of approximately 200 acres, of which 170 acres were of the Southport White Globe variety and 32 acres were of the Yellow Sweet Spanish variety. Of this planting, 175 acres were sprayed and 25 were dusted. The location of this planting was on Holland Island in the Sacramento River Delta region and was divided by irrigation ditches and headlands into two 25-acre plots, two 50-acre plots, and four plots of approximately 13 acres each. The plots were surrounded by crops of wheat, sugar beets, asparagus, and beets planted for seed. The irrigation ditch banks were rank with growth, including cattails on which thrips were present throughout the season. The prevailing winds were from the southwest; apparently they were the main means of thrips distribution since all plot margins on the south and the west carried the heaviest infestations.

The onion seed was machine-planted, beginning March 7 for the white variety and March 26 for the yellow, at a rate of 5 to 5½ pounds per acre. The row spacing was 16-16-12-12-12 inches, which permitted the pneumatic tires of tractor and spray trailer adequate space. The seedlings were showing aboveground early in May and, with frequent irrigations and cultivations, had attained the fourth leaf in top growth early in June. Thrips populations at this stage of growth averaged 12 adults and 8 nymphs per plant and the preliminary field tests were started on June 5.

The spray equipment used consisted of a Bean Royal 20-gallons-per-minute pump, a 6 hp. gas engine, and a 300-gallon tank, all mounted on a pneumatic-tired trailer which was drawn by a tractor. The spray boom had 8 single mist nozzles with 5/64-inch disk openings; each nozzle had the center of the vortex plate bored to give a solid cone spray. The nozzles were spaced on the boom to cover each row in a swath 8 feet wide, and the boom was adjustable to height so as to give a complete spray pattern at the ground level. With a pressure of 200 pounds on the spray discharge line a coarse driving spray was obtained from the nozzle. The speed of the tractor was such that the 300-gallon tank of spray covered four strips across each plot, or an area of one acre. An average of 14 tanks per day was applied. One operator drove the tractor and another operator, riding at the rear end of the trailer, kept the nozzles in proper adjustment.

In preliminary tests, a tank of each spray combination was applied and compared for wetting, deposit, and thrips control at the time of application and several days later.

The DDT used was a commercial 25 per cent wettable powder using an eastern clay as a filler and was tested at dosages of 5 and 7½ pounds per 300

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gallons of water or an actual DDT concentration of approximately $\frac{4}{10}$ and $\frac{6}{10}$ pound per hundred gallons of spray. With a good wetter and depositor the lesser dosage was apparently satisfactory and was used throughout the control. The onion tops were very difficult to wet, especially on the leaf axils where the thrips were the most numerous. To obtain satisfactory wetting, thirty spray combinations, involving numerous wetting agents, were tested. The following wetting agents and spreaders were used at various dosages with and without kerosene: Savolin, Orthex, blood albumin, Dupont sticker and spreader, Quicksolv, DDT depositor, B-1956 and Spraon.

Following are some of the more important spray combinations tested. The amount of materials given is sufficient to make 300 gallons of spray.

1. DDT wettable powder, 5 pounds; B-1956, 1½ pints; DDT depositor, 3 pounds; kerosene, 3 quarts.
2. DDT wettable powder, 5 pounds; Savolin, 3 pounds; kerosene, 3 quarts.
3. DDT wettable powder, 5 pounds; DDT depositor, 3 pounds; kerosene, 3 quarts.
4. DDT wettable powder, 5 pounds; Dupont sticker and spreader, 1½ pints; DDT depositor, 3 pounds; kerosene, 3 quarts.
5. DDT wettable powder, 5 pounds; Black Leaf 155, 4½ pounds; B-1956, 1½ pints.
6. DDT wettable powder, 5 pounds; Botano N, 10 pounds; DDT depositor, 3 pounds; B-1956, 1½ pints.
7. DDT wettable powder, 5 pounds; DN-111, 3 pounds; Savolin, 3 pounds.
8. Tanatox, 6 pounds; DDT depositor, 3 pounds; kerosene, 3 quarts.
9. Loro, 3 quarts; Dupont sticker and spreader, 3 pints.
10. A commercial product containing 7 per cent nicotine alkaloid and 17 per cent DDT, 9½ pounds; Savolin, 3 pounds.
11. Same as preceding, plus DDT depositor, 3 pounds; kerosene, 3 quarts.
12. Lethane B-72, 7½ pounds; B-1956, 1½ pints.

Spray combinations 1 to 4 gave the best coverage and control, but because of availability, formula 1 was selected for treating the acreage outside of that used for the preliminary testing. Other formulas showing much promise were 5, 6, 8, 10 and 11, but none of these were available in sufficient amounts for extensive testing.

The first application of spray over the entire area, including the experimental work, extended from June 5 to June 25; the second application, from June 25 to July 13. A partial third treatment was required along the western margins of certain blocks where the heaviest populations occurred. Spray operations were necessarily made to synchronize with irrigation practices. Irrigations by the overhead rain-maker system were given at intervals of from 7 to 13 days and were undoubtedly a factor in reducing the build-up of thrips populations, especially after the thrips began to move out on the leaves.

Frequent thrips counts were made in different sections of the sprayed area, but in none of these did the thrips populations increase to a level where any apparent injury to the onions occurred. The tops were green and strong when harvesting began August 15. The average yield was 25,000 pounds per acre which, though not a high yield, was well above the yield obtained in adjoining fields.

Two plots of approximately 13 acres each were dusted with DDT dusts on July 5 and July 14 by using a power row-crop duster and a dosage of 50 pounds per acre. The thrips populations before treatment were very high in these plots, because they were located on the heavily infected west margin of the field. One plot received a 5 per cent dust in the first application and a 3 per cent dust in the second. The other plot received 3 per cent dust in both applications. The control in these plots was not so satisfactory as that in the plots which received a wet spray, although there was less damage in the plot receiving the 5 per cent dust.

PRELIMINARY EXPERIMENTS TESTING DDT AND OTHER MATERIALS FOR CONTROL OF ONION THRIPS ON PINK BEANS IN THE SUTTER BASIN[36]

W. H. LANGE, Jr.[37]

Onion thrips cause periodic damage to Pink beans planted in the Sutter Basin. The last major outbreak was in 1942, and control measures developed at that time and used subsequently consisted of a spray of tartar emetic and sugar. The recent success with DDT for controlling onion thrips on onions and the present difficulty in obtaining tartar emetic and sugar suggested that experiments using DDT and other materials in various combinations should be tried.

Materials Used.—Two sets of experiments were conducted, and one experimental commercial application was made. In the first set of experiments the following mixtures were used:

1. DDT wettable powder (20 per cent DDT), 5 pounds; water to make 15 gallons.
2. DDT wettable powder (20 per cent DDT), 5 pounds; white granulated sugar, 5 pounds; water to make 15 gallons.
3. DDT oil emulsion (Gesarol oil DDT concentrate containing 20 per cent DDT), 1 gallon; DDT colloidal depositor, 0.5 pounds; sulfonated vegetable oil, 300 cc; water to make 15 gallons.
4. Tartar emetic, 2 pounds; white granulated sugar, 2 pounds; water to make 10 gallons.
5. DDT sulfur dust (4 per cent DDT, 85.8 per cent sulfur, 10.2 per cent inert).
6. Trichloro-chloro-phenyl-phenyl-ethane (Tanatox), 20 per cent dust.
7. DDT dust, 3 per cent, with no sulfur.

In the second set of experiments, varying dosages of a vapo-spray oil containing DDT were used. The spray consisted of 2.4 per cent DDT in oil[38] used at the following rates per acre: 2.9 gallons, 5.8 gallons, and 8.7 gallons.

In addition to these experiments, a 4 per cent DDT-sulfur dust (85 per cent sulfur) was applied to a 10-acre experimental commercial field.

[36] The author acknowledges the assistance of the following individuals in conducting these trials: W. E. Ball, G. J. Henle, Jr., J. R. Henle, and W. J. Duffy, Jr.

[37] Assistant Entomologist in the Experiment Station.

[38] Composition of oil: 70 per cent mineral seal oil of 45 to 50 viscosity (90 U.R.); and 30 per cent kerosene.

Method of Application.—The materials were applied by means of a combination duster sprayer, or Naconizer, which made it possible to use water and oil-base sprays as well as dusts. In the application of the 4 per cent DDT dust to the 10 acres of beans, water was used through the vaporizers in order to insure a good deposit on the plants.

TABLE 11

RESULTS OF DUST AND VAPO-SPRAY TREATMENTS APPLIED TO PINK BEANS JULY 31, 1945, FOR CONTROL OF ONION THRIPS

Materials	Number of thrips per plant, Aug. 6		Per cent control, August 6		Number of thrips per plant, Aug. 20		Per cent control, August 20	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
Sprays								
DDT 20 per cent wettable powder, 5 pounds; water, 15 gallons.......	5.3	1.2	61.3	70 7	46.8	10.5	7.0	0.0
DDT 20 per cent wettable powder, 5 pounds; white granulated cane sugar, 5 pounds; water, 15 gallons	8.2	1.3	40.1	68.3	22.8	3.5	54.7	50.0
DDT oil concentrate* (20 per cent DDT), 1 gallon; DDT colloidal depositor, 0.5 pound; sulfonated vegetable oil, 300 cc; water, 15 gallons..........................	2.3	0.0	83.2	100.0	21.0	4.7	54.3	32.9
Tartar emetic, 2 pounds; sugar, 2 pounds; water, 10 gallons........	1.8	0.6	86.9	85.4	15.2	4.7	65.8	32.9
Dusts								
DDT, 4 per cent; sulfur, 85.8 per cent; inert, 10.2 per cent.........	0.6	0.0	95.6	100.0	12.9	3.5	70.1	50.0
Trichloro-chloro-phenyl-phenyl-ethane (Tanatox), 20 per cent; inert, 80 per cent................	1.8	0.6	86.9	95.6	17.5	9.4	65.2	0.0
DDT, 3 per cent; inert, 97 per cent.	0.6	0.6	95.6	95.6	7.0	3.5	84.6	50.0
Check, untreated.................	13.7	4.1	....	....	50.3	7.0	....	....

* Gesarol oil DDT concentrate.

Results of Tests.—In the first set of experiments the materials were applied to early Pink beans at the prebloom stage on July 31, 1945. The materials were applied with the Naconizer, in amounts of 5 to 6 gallons of the liquid materials, and 40 pounds of the dusts per acre.

On August 6 and August 20, from each plot 20 and 15 plants, respectively, were examined; the results of thrips counts with the corresponding per cent of control is summarized in table 11. These counts indicated that all of the treatments gave good control on August 6, a week following treatment, except the DDT wettable powder and the DDT wettable powder and sugar.

On August 20, the 3 and 4 per cent dusts again gave the best control, with the tartar emetic and sugar only slightly less effective. The DDT wettable powders and DDT oil concentrate did not give a lasting effect and the control was not satisfactory on August 20. On August 6, it was apparent that the

20 per cent trichloro-chloro-phenyl-phenyl-ethane dust was causing considerable injury to the plants. The older foliage especially turned yellow and fell to the ground. By August 20, however, the plants partially recovered and set a fair crop of beans. The DDT oil concentrate caused spotted burning of the leaves, but no permanent injury. It was also noticeable that where the plants received a heavy dosage of the DDT wettable power—which occurred when the machine stopped over the beans—the plants were seriously stunted and did not recover for several weeks. No injury could be detected with the 3 and 4 per cent DDT dusts.

On August 20 a series of vapo-spray treatments was applied through the Naconizer by using 2.9, 5.8, and 8.7 gallons per acre of a 2.4 per cent DDT in a vapo-spray oil on beans in the prebloom stage. The plots were 8 rows

TABLE 12

RESULTS OF APPLYING DDT VAPO-SPRAY OILS TO PINK BEANS ON AUGUST 20, 1945, FOR CONTROL OF THE ONION THRIPS

Material and amount used per acre	Number of thrips per plant, August 27		Per cent control, August 27		Number of thrips per plant, September 18		Per cent control, September 18	
	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults	Nymphs	Adults
DDT, 2.4 per cent in vapo-spray oil; at 2.9 gallons..	10.5	28.1	87.5	7.9	25.7	5.8	21.4	0.0
DDT, 2.4 per cent in vapo-spray oil; at 5.8 gallons..	2.3	10.5	97.3	65.6	57.3	4.7	0.0	0.0
DDT, 2.4 per cent in vapo-spray oil; at 8.7 gallons..	2.3	9.4	97.3	70.3	52.6	9.4	0.0	0.0
Check, untreated.........	76.0	16.4	....	....	24.5	3.5	....	....
Second check, untreated..	92.3	45.6	....	....	40.9	5.8	....	....

wide by 1,200 feet long, and approximately four fifths of an acre in extent. Two of the plots were left untreated to serve as checks. The results of these experiments are summarized in table 12. One week following treatment the 5.8- and 8.7-gallon applications per acre gave excellent reduction in nymph populations, but by September 18 no carryover effect of the treatments was found. On August 27, one week after treatment, the lower leaves on the plants treated with the 5.8- and 8.7-gallon treatments showed chlorotic areas giving a mottled appearance to the leaves. The 8.7-gallon treatment also stunted some of the plants. On September 18 the plants had largely recovered, although the affected plants had yellower lower leaves and more leaf drop than normal plants.

On July 30, a 4 per cent DDT dust with sulfur[39] was applied with a Naconizer to a 10-acre field at the rate of 35 pounds per acre. The plants had already set a good crop of beans. An examination on July 31 indicated almost a perfect control of thrips at this time. On August 6 the treated plant had 10 nymphs per plant compared with 78 nymphs per plant in an untreated strip area. On August 20, the treated plants had 10 nymphs per plant compared with 15 nymphs per plant on the untreated plants.

[39] The sulfur and DDT were intimately fused: composition, 4 per cent DDT, 85.8 per cent sulfur, 10.2 per cent inert.

Discussion of Results.—The results of these preliminary experiments indicate that a 3 or 4 per cent DDT dust, preferably with sulfur in order to partially control red spiders, is a satisfactory substitute for a tartar emetic spray. Growers in the Sutter Basin area who use Naconizers have been adding 10 pounds of tartar emetic and 20 pounds of sugar to the 60-gallon tank. This has been applied at the rate of 5 to 6 gallons of spray per acre. This would correspond roughly to 1 pound of tartar emetic and 2 pounds of sugar per acre. In these experiments there is some indication that the 1:2 tartar emetic sugar ratio could be cut to 1:1; in this way sugar could be conserved and cost of application could be reduced. A commercial operator in this vicinity has been using 6 pounds of tartar emetic and 12 pounds of sugar to 100 gallons of water, and has applied the mixture at about 30 gallons of spray per acre. One application applied just before blooming usually gives an adequate control of thrips for the season.

There is some indication that DDT as a dust remains effective at least 20 days in the field, and in this respect compares favorably with a tartar emetic and sugar spray. The dust application should be made just prior to blooming.

As is true with tartar emetic and sugar, these experiments would indicate that a single application just prior to blooming time would give control for the season. A second application might be necessary in 10 to 15 days in years of severe thrips damage. Applications made later in the growth of the plants are not feasible by ground application because of the extensive mechanical injury caused to the plants by the wheels of the applicator.

Because of the danger of plant injury, mixtures of DDT in oil are not recommended for use on beans. Trichloro-chloro-phenyl-phenyl-ethane (Tanatox) as a 20 per cent dust seriously injured beans and should not be applied at this strength.

It is well at this time to caution growers that DDT should not be applied to beans where the straw will be fed to livestock. Until the full effects of DDT applications on Pink beans are known, it is also well to apply the insecticide to limited acreages.

EXPERIMENTS WITH DDT AND LEAD ARSENATE FOR CONTROLLING THE PEA LEAF MINER AND OTHER PEA INSECTS

LESLIE M. SMITH[40] AND W. H. LANGE, JR.[41]

Experiments conducted at Gilroy during 1944[42] indicated that two applications of a mixture of oil and DDT, applied as a vapo-spray, were effective in controlling the pea aphid, and lepidopterous larvae. There was also evidence that DDT killed adult flies of the pea leaf miner, although no conclusive results were obtained at that time.

The pea leaf miner, *Liriomyza flaveola* (Fallén), is an important pest of peas, particularly fall peas, in certain coastal districts where its destructiveness is periodic, depending on weather conditions, emergence from other hosts, efficiency of its numerous parasites, and possibly other factors. The maggots mine the leaves and stems; occasionally they mine the pods and thus reduce the quality of the market peas.

The present experiments were conducted near Santa Clara, in Santa Clara County, in an area where pea leaf miner, pea aphid, and thrips cause considerable damage to fall peas.

The materials tested consisted of four dust combinations with DDT, one dust containing lead arsenate and sulfur, and one DDT and oil mixture applied as a vapo-spray. The compositions of the different dust combinations used were as follows: DDT, 4 per cent, sulfur, 85 per cent, and inert, 11 per cent; DDT, 3 per cent, sulfur, 50 per cent, frianite, 37 per cent, and diatomaceous earth, 10 per cent; DDT, 3 per cent, talc, 4 per cent, diatomaceous earth, 10 per cent, and frianite, 83 per cent; DDT, 5 per cent, inert, 95 per cent (no sulfur); and standard lead arsenate, 25 per cent, sulfur, 72 per cent, inert, 3 per cent. The vapo-spray used contained 2.4 per cent (by weight) DDT in a vapo-spray oil base. The effects of these combinations were compared with those in the untreated check areas.

The field selected for these experiments comprised 18 acres planted to Morse 60 market peas. The plots were 12 rows wide (about 40 feet) and 300 feet long. Data were compiled from eight replications for each of the treatments, except the vapo-spray treatment where four replications were used. The treated plots were compared with 4 untreated blocks.

Applications of the dust mixtures were made on July 24, August 4, August 14, August 24, and September 2. A tractor-mounted power duster with power take-off was used to apply the dusts and 35 to 50 pounds of dust per acre were used for each application. The vapo-spray was applied on August 3, August 15, August 25, and September 3, using 3.5 gallons of material per acre for each treatment. At the time of the first application on July 24 the peas had about three true leaves.

[40] Associate Entomologist in the Experiment Station.

[41] Assistant Entomologist in the Experiment Station.

[42] California Agricultural Experiment Station. Investigations with DDT in California, 1944. (A preliminary report prepared under the direction of the Division of Entomology and Parasitology.) (Lithoprinted.) 33 p. March, 1945.

On August 14 an examination of plants in the different plots indicated that the most satisfactory index to control of the pea leaf miner was obtained by counting the number of mines on the fifth leaf from the base of the plants. It was apparent at this time that some adult flies had deposited eggs in the leaves before the first application on July 24, and it was for this reason that the fifth leaf was selected. According to these counts, some degree of control of the miner was obtained from the 5 per cent DDT dust, the standard lead

TABLE 13

RESULTS OBTAINED IN FIELD EXPERIMENTS AT SANTA CLARA USING DDT AND LEAD ARSENATE FOR PEA INSECT CONTROL*

Dust and vapo-spray materials	Average number of mines of pea leaf miner per leaf		Average number of pea aphids per plant	Average number of thrips per plant		Average number of rough pods (pod mosaic) per plant	Average number of lepidopterous larvae per plant
	Fifth leaf from bottom, Aug. 14	Fifth leaf from top, Sept. 21		Nymphs	Adults		
DDT (fused with sulfur), 4 per cent; sulfur, 85 per cent; inert, 11 per cent	1.4	16.1	0.2	0.8	4.0	0.0	0.2
DDT, 3 per cent; sulfur, 50 per cent; frianite, 37 per cent; diatomaceous earth, 10 per cent	1.4	14.3	1.2	0.9	4.1	0.03	0.3
DDT, 3 per cent; talc, 4 per cent; diatomaceous earth, 10 per cent; frianite, 83 per cent	1.1	17.1	1.5	1.3	4.0	0.2	0.1
DDT, 5 per cent; inert, 95 per cent (no sulfur)	0.8	9.7	1.5	0.9	4.2	0.04	0.01
Standard lead arsenate, 25 per cent; sulfur, 72 per cent; inert, 3 per cent†	0.8	6.3	5.5	3.3	15.4	0.1	0.3
DDT, 2.4 per cent in a vapo-spray oil‡	0.7	14.3	1.7	0.6	3.2	0.0	0.1
Untreated	2.0	22.2	10.9	2.5	9.0	0.9	0.4

* Dusts applied July 24, August 4, August 14, August 24, and September 2. Vapo-sprays applied August 3, August 15, August 25, and September 3.

† Arsenic expressed as metallic, 4.87 per cent.

‡ Composition: 70 per cent mineral seal oil of 45 to 50 viscosity (90 U.R.) and 30 per cent kerosene.

arsenate dust, and the DDT vapo-spray. On September 20, from each plot 12 plants (96 for eight replications) were collected and examined carefully in the laboratory for mines, number of aphids, number of thrips, number of lepidopterous larvae, number of mosaic plants, and number of rough pods caused by the rough-pod mosaic. In this series of counts it was found that the best index to control of the pea leaf miner was obtained by a careful examination of the mines on the fifth leaf from the top of the plant. The numbers of aphids, thrips, and lepidopterous larvae were determined by counting those occurring on the top five leaves of the plants. The rough pod peas were counted on the terminal growth back to and including the fifth leaf.

Results.—The results of these experiments are summarized in table 13. In regard to control of the pea leaf miner it would seem that the lead arsenate sulfur dust gave the best reduction in numbers of mines, with 6.3 mines per fifth leaf as compared with 22.2 for the checks. The 5 per cent DDT dust was

the next most effective dust with 9.7 mines per fifth leaf, followed by the other treatments which gave 14.3 to 17.1 mines per fifth leaf. With the exception of the vapo-spray treatment, it is interesting to note that the trends for control of the pea leaf miner were the same on August 14 and September 20.

As with the 1944 results, the control of the pea aphid, *Macrosiphum onobrachis* (B. de F.) was satisfactory with all the DDT preparations. There was some evidence that the DDT-sulfur mixtures were superior to DDT with other carriers.

Some evidence of the control of thrips, chiefly *Thrips tabaci* Lind., was obtained with the DDT preparation. It was interesting to note that the combination of lead arsenate and sulfur dust tended to build up thrips populations to a higher level than the untreated checks.

The pea aphid is the chief agent in carrying the pod-deforming mosaic of peas, and it was very evident by field and laboratory counts that the untreated check plants had a higher percentage of mosaic plants and a higher percentage of rough pods. The DDT-treated plants were noticeably free from mosaic and rough pods, probably because of the aphid control.

The DDT preparations as evidenced by these experiments gave good control of various lepidopterous larvae, particularly those of the sugar beet army worm, *Laphygma exigua* (Hbw.), which was the most abundant species present.

Just before harvest, pods were picked at random and analyzed for DDT. Even though as many as five DDT applications (3 and 5 per cent dusts) were made, the analysis showed a DDT residue of far less than the tentative tolerance of 7 p.p.m. The results of these tests are given in table 36 (p. 105).

The results presented herewith are considered preliminary; additional investigations will be required before DDT or other chemicals can be recommended for pea insect control.

TESTS USING DDT AND OTHER MATERIALS FOR CONTROL OF THE PEA APHID[43]

W. H. LANGE, JR.[44]

During 1944 the pea aphid, *Macrosiphum onobrachis* (B. de F.), caused severe damage to seed peas planted in the King City area of Monterey County. The experiments described in this paper were designed with a two-fold purpose: (1) to compare the use of DDT with other materials used in this area; and (2) to find a substitute for nicotine dusts, which have been obtainable only in limited amounts. The growers were equipped only with dusters and so it was decided to confine these tests to dust materials.

TABLE 14
COMPARATIVE EFFECTIVENESS OF DIFFERENT INSECTICIDAL DUSTS FOR CONTROLLING THE PEA APHID AT KING CITY*

Dust used and amount per acre	Number of pea aphids per plant on May 4	Per cent control on May 4
Nicotine alkaloid, 3.6 per cent; inert, 96.4 per cent, at 80 pounds	5.5	55.3
Beta beta′ dithiocyanodiethyl ether, 2.25 per cent; sulfur, 23.0 per cent; inert, 74.75 per cent; at 100 pounds	6.6	46.3
DDT, 2 per cent†; sulfur, 89.7 per cent; inert, 8.3 per cent; at 75 pounds	3.1	74.8
DDT, 4 per cent‡; sulfur, 85.8 per cent; inert, 10.2 per cent; at 70 pounds	0.3	97.6
Check, untreated‡	12.3	....

* Dusts applied with a power duster, April 12, 1945.
† DDT fused with the sulfur.
‡ Average of 4 untreated areas.

The dusts were applied April 12, 1945, in the same area to the Shasta variety of peas planted for seed purposes. The plants at this time had passed full bloom and many small pods were present. The population of aphids at this time was not high, as sweepings made in the check areas on April 12 gave about 3 aphids per sweep based on the average of 100 sweeps in each plot. The materials were applied by means of a power duster to plots varying from one quarter to 2 acres in extent, replicated twice, along with several untreated checks. The materials were applied at heavier applications per acre than normally used in order to increase the lasting effect of the insecticides. This was done because the vines were just about to close the rows and further treatments would be impracticable.

The dust materials used were as follows: nicotine dust containing 3.6 per cent nicotine as alkaloid (a so-called "free" nicotine dust), inert, 96.4 per cent; beta beta′ dithiocyanodiethyl ether, 2.25 per cent, sulfur, 23 per cent, inert, 74.75 per cent; DDT, 2 per cent, sulfur 89.7 per cent, inert, 8.3 per cent; and DDT, 4 per cent, sulfur 85.8 per cent, inert, 10.2 per cent.

On May 4, population counts were made by jarring the aphids from groups of 12 plants onto a large cardboard and counting the number of live ones. The

[43] This work was initiated through the Farm Bureau of Monterey County with the assistance of T. W. Thwaits.
[44] Assistant Entomologist in the Experiment Station.

results of three such counts for each plot are summarized in table 14. These indicate that the 4 per cent DDT-sulfur dust was superior to the other materials. On May 9 and May 21 sweeps were made in each of the plots, usually 50 to 100 in each, and the number of aphids were recorded. Since the pea leaf miner *Liriomyza flaveola* (Fallén) is also an important pest on peas, incidental counts were also made of that insect. On May 9 only 0.1 aphid per sweep was recorded in the 4 per cent DDT-sulfur plots, and on May 21 only 0.2 aphid per sweep. The untreated areas on these dates averaged 2 aphids per sweep. The number of pea leaf miner adults averaged 4 per sweep on May 9 in the untreated areas and 3 to 5 in the treated. On May 21 the untreated areas averaged 0.7 fly per sweep and the treated areas 0.1 to 0.8 fly per sweep. There was apparently no correlation between the number of flies and the treatments. Yields taken on June 30 indicated a 7 per cent increase of peas in the 4 per cent DDT plots as compared with the untreated areas.

The results of these tests would indicate that a 4 per cent DDT-sulfur dust is more effective in the control of the pea aphid on seed peas in the King City area than a 2 per cent DDT-sulfur mixture, a thiocyanate dust, or a nicotine dust. The use of sulfur with the DDT seems desirable not only from the standpoint of control, but also as a preventive treatment for mildew. Until further tests are carried out, DDT should not be recommended on a large scale for use on peas, and peas dusted with DDT should not be fed to livestock.

TWO NEW SOIL FUMIGANTS, D-D AND EDB FOR WIREWORM CONTROL[45]

W. H. LANGE, JR.[46]

The use of soil fumigants for wireworm control in the past has been a costly method, largely restricted to small areas of infested land. Experiments conducted since 1943, however, have indicated that with the two relatively new fumigants, D-D (dichloropropane-dichloropropene) and EDB (ethylene dibromide), it is possible to control wireworms economically on a large-scale basis. This has also been accomplished through the development of new application equipment for these fumigants. In the Salinas Valley both of these chemicals have been applied on a commercial basis. The experiments reported in this paper are those conducted during 1945 in the Salinas and Sacramento valleys, in which the two fumigants were directly compared in the same fields.

Materials Used.—D-D is a dark liquid consisting chiefly of 1,2-dichloropropane and 1,3-dichloropropene, and also containing minor percentages of other lighter and heavier hydrocarbons, saturated and unsaturated. This fumigant was first used primarily as a nematocide by Carter.[47] Stone[48] reported

[45] The D-D soil fumigant was supplied by the Shell Chemical Company of San Francisco; the ethylene dibromide by the Dow Chemical Company of Midland, Michigan.

[46] Assistant Entomologist in the Experiment Station.

[47] Carter, Walter. A promising new soil amendment and disinfectant. Science (n.s.) 97:383–84. 1943.

Soil treatments with special reference to fumigation with D-D mixture. Jour. Econ. Ent. 38(1):35–44. 1945.

[48] Stone, M. W. Dichloropropane-dichloropropylene, a new soil fumigant for wireworms. Jour. Econ. Ent. 37(2):297–99. 1944.

its use for wireworm control in California in emulsion form. In the present tests the fumigant was used undiluted.

EDB, or ethylene dibromide (1,2-dibromoethane), is a colorless liquid supplied as a 10 per cent (by volume, or 20 per cent by weight) solution dissolved in a naphtha 200-base thinner.

Fig. 11.—Applicators used in applying soil fumigants: upper, D-D applicator; lower, ethylene dibromide applicator.

Method of Application.—The materials were applied by means of two commercial trailer applicators having a series of drills (spaced from 12 to 15 inches apart), and drilled into the soil as a continuous stream at a depth of from 6 to 8 inches. The fumigants were forced into the ground under low pressures, and the dosage was controlled by regulating the speed of the tractor, the size of the orifice, and the pressure at which the fumigant was applied.

The soil in all tests was in good friable condition, ready for planting. In some instances a drag or roller was used to seal the surface of the soil. The two types of applicators used are shown in figure 11.

Results of Tests at Salinas.—On December 10, 1944, ethylene dibromide (15 per cent by volume) was applied to a field at Salinas in replicated ⅛-acre plots; the rest of the field was treated commercially with 400 pounds of D-D and 35 pounds of anhydrous ammonia per acre. The temperature on this date was 50°F at an 8-inch depth, and the fumigant was applied with the Shell commercial applicator as a continuous stream at a depth of 8 inches with 15-inch spacings. The soil type was Salinas silty clay loam, and the field was in good condition for planting. Lettuce was planted 10 days after treatment, with the expectation that the December rains would germinate the seed. The results of this test indicated that the combination of either fumigant, especially with the simultaneous application of anhydrous ammonia, gave substantial increases in yields of lettuce on wireworm-infested soil. The results are summarized in table 15.

TABLE 15

EFFECT OF ETHYLENE DIBROMIDE AND D-D APPLIED TO A LETTUCE FIELD INFESTED WITH THE SUGAR BEET WIREWORM, AT SALINAS

(Applied on December 10, 1944)

Materials and rate of application per acre	Per cent of lettuce plants found damaged, April 5, 1945	Calculated number of 80-pound, trimmed crates of lettuce per acre
D-D, 40 gallons; and anhydrous ammonia, 35 pounds	0.14	249
Ethylene dibromide (15 per cent by volume), 42 gallons; and anhydrous ammonia, 30 pounds	0.12	298
Ethylene dibromide (15 per cent by volume), 42 gallons	0.36	189
Ethylene dibromide (15 per cent by volume), 50 gallons	0.40	214
Untreated	5.57	173

At Salinas on June 4, 1945, another trial was initiated where a dosage of 40 gallons of D-D was compared with 40 gallons of 5 per cent ethylene dibromide, and with untreated checks in a field heavily infested with sugar beet wireworms. The plots were 30 feet wide by 500 feet long. Three replications were used for each treatment, with check strips of similar width left between each treated area. The materials were applied with the Shell commercial applicator, using 15-inch spacings at a depth of 8 inches. On September 20, 1945, when yields were checked, the plots treated with 40 gallons of D-D yielded 408.3 80-pound crates of trimmed lettuce, the ethylene dibromide, 289.1 crates, and the untreated checks 58.2 crates per acre. A view of the results obtained with these treatments is shown in figure 12.

Results of Tests in the Sacramento Valley.—During 1945, tests were conducted in the northern Sacramento Valley at Gridley and Meridian to test the relative efficacy of different dosages of D-D and ethylene dibromide. D-D was tested at 20, 40, and 60 gallons per acre; ethylene dibromide (10 per cent by volume) at 30 and 40 gallons per acre; and these compared with untreated

checks. Three replications arranged as randomized blocks 25 feet wide by 200 feet deep were used. The ethylene dibromide was applied with the Dow commercial applicator and the D-D by the Shell experimental applicator. Both machines applied a continuous stream of fumigant to a depth of from 6 to 8 inches.

At Gridley the fumigants were applied May 1, 1945. The temperature at the 6-inch level was 87° F and at the 12-inch level, 73° F; the soil moisture content was 9.1 per cent. The soil was Columbia fine sandy loam. Baby lima beans were planted 2 weeks after the treatment. On June 20, stand counts

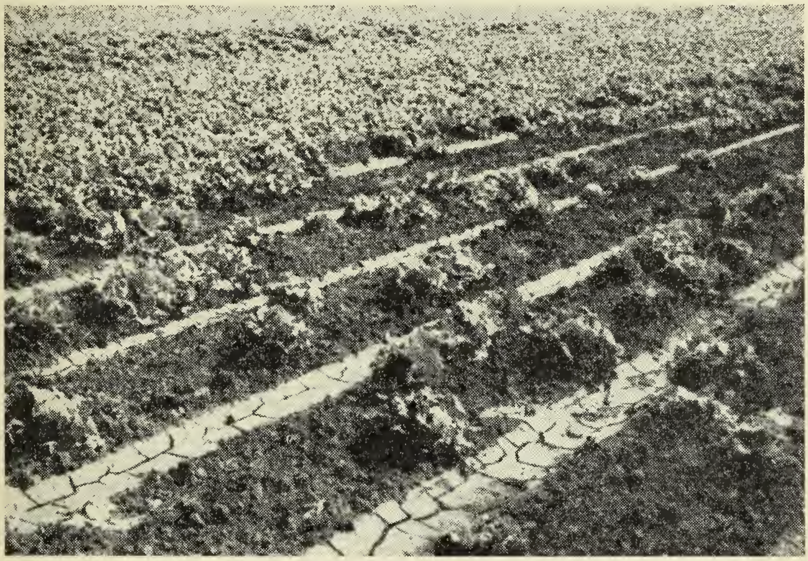

Fig. 12.—Results of soil fumigation tests at Salinas: foreground, untreated; background, treated with 400 pounds of D-D.

indicated no significant difference between the different treatments, but soil siftings to the depth of 10 inches indicated that both ethylene dibromide treatments gave a complete kill of wireworms to the depth at which the samples were taken. The higher dosages of D-D, 40 and 60 gallons per acre, also gave an excellent kill of wireworms. It was observed that siftings to a depth of 10 inches do not always give a complete record of the kill as a few wireworms at a greater depth in the soil may have escaped the treatment. The results of this experiment are shown in table 16.

At Meridian a similar test was conducted on May 2. The soil was Columbia silty clay loam and the temperature at the 6-inch level was 70°F, at 12 inches it was 68°F, and the soil moisture content was 14 per cent. Baby lima beans were planted in 2 weeks. The results of these tests indicated that on June 7, on the basis of stand counts, the ethylene dibromide treatments gave a protection from wireworm comparable with the 60-gallon-per-acre treatment of D-D. The results are summarized in table 17.

Discussion.—From the results obtained it seems that both D-D and ethylene dibromide offer good possibilities for the economical control of wireworms in

land under irrigation and intensive cultivation in California. Tests reported herein, and others over a period of two years, have shown that D-D used at 40 gallons (400 pounds) per acre, although not effecting a complete kill of wireworms, offers the most economical control and the greatest returns. The simultaneous application of 35 pounds of ammonia with the fumigant, particularly in late fall treatment, gave the greatest yields when followed by

TABLE 16

RESULTS OF TESTS COMPARING DIFFERENT DOSAGES OF D-D AND ETHYLENE DIBROMIDE FOR WIREWORM CONTROL AT GRIDLEY

(Applied May 1, 1945)

Materials and rate of application per acre	Number of lima bean plants per foot of row	Per cent reduction in number of wireworms*
D-D, 20 gallons	1.89	75
D-D, 40 gallons	1.90	92
D-D, 60 gallons	1.81	100
Ethylene dibromide (10 per cent by volume), 30 gallons	2.13	100
Ethylene dibromide (10 per cent by volume), 40 gallons	1.81	100
Check	0.87	...

* Based on total number of wireworms in 8 one-square-foot samples of soil to a depth of 10 inches for each treatment.

TABLE 17

CONTROL OBTAINED WITH ETHYLENE DIBROMIDE AND D-D ON LIMA BEANS, AT MERIDIAN

(Counts taken June 7, 1945)

Materials and rate of application per acre	Number of lima bean plants damaged by wireworms on 1/24 acre	Per cent of lima bean plants damaged by wireworms
D-D, 20 gallons	70	2.8
D-D, 40 gallons	78	3.2
D-D, 60 gallons	33	1.3
Ethylene dibromide (10 per cent by volume), 30 gallons	30	1.3
Ethylene dibromide (10 per cent by volume), 40 gallons	11	0.5
Check	229	11.9

lettuce. It is probable that the reduction in numbers of wireworms together with the presence of ammoniacal nitrogen in the spring accounts for the more rapid growth, greener color, and greater yields where the combination fumigant-fertilizer is used. The recent work by Tam[49] might indicate that the 40-gallon-per-acre treatment of D-D suppresses nitrification for a limited period and in this interim the lettuce plant is able to utilize ammoniacal nitrogen supplied at the time of application of the fumigant. This additional nitrogen was not used as a substitute for the regular fertilizer program using balanced commercial fertilizers or manure.

It would seem from these tests that EDB can be used at lower dosages to

[49] Tam, R. K. The comparable effect of a 50-50 mixture of 1, 3 dichloropropene and 1, 2 dichloropropane (D-D mixture) and of chloropicrin on nitrification in soil and on growth of the pineapple plant. Soil Sci. 59(3):191–205. 1945.

obtain wireworm control than can D-D. The resultant crop yields, however, can only be ascertained by future tests using all types of crops. For example, beans following EDB often show better growth than can be explained on a basis of the control of wireworms alone. On the other hand, if beans are planted too soon following the higher dosages of D-D, damage will result. The fumigant used in particular instances may have to be chosen on a basis of the crop to be treated.

Summary.—Tests comparing different dosages of D-D (dichloropropane-dichloropropene) and EDB (ethylene dibromide) conducted at Salinas, Meridian, and Gridley, California, during 1944–45 indicated that these fumigants offer good possibilities for the economical control of wireworms when applied in continuous streams at a depth of from 6 to 8 inches and 12- to 15-inch spacings. With D-D, a dosage of 40 gallons (400 pounds) per acre gives a satisfactory reduction in wireworms and subsequent increased yields of lettuce and beans.

The simultaneous application of 35 pounds of anhydrous ammonia with 40 gallons of D-D in the fall, gave the greatest increases in yields of lettuce the following spring.

EDB (10 per cent by volume) at both 30 and 40 gallons in a naphtha 200-base thinner per acre, was found to give good kills of wireworms, resulting in better stands and increased yields. This dosage compared favorably in most cases with 40 to 60 gallons of D-D from the standpoint of actual kill of wireworms, although the increased yields following the treatment may depend upon the crop to be planted and other factors, such as the interval of time between fumigation and date of planting.

CONTROL OF ROOT-KNOT NEMATODE WITH D-D MIXTURE AND CHLOROPICRIN[50]

M. W. ALLEN[51]

The root-knot nematode is one of the most important plant pests occurring in California. In general it is most injurious in the interior valleys, but it also occurs in the coastal areas. This pest is responsible for a considerable amount of damage to certain truck crops, fruit trees, and ornamentals. Control measures, only partially successful, usually involve crop rotations, summer fallow, and the growing of resistant or immune crops. Chemical control has, in the past, generally proved to be impractical because of the excessive cost of the chemicals and the difficulties encountered in making applications over large areas.

D-D, a crude mixture of 1,3-dichloropropene and 1,2-dichloropropane, containing small amounts of other saturated and unsaturated hydrocarbons, was first used as a nematocide in Hawaii and subsequently has been used experimentally by many workers in the United States. Commercial applications in the United States have been largely limited to the Pacific Coast, more especially California. The experiment reported here was to determine, if possible, the dosage of D-D required to give most economical control. A Latin square experimental design was used, with six replications of each treatment. The plots were 20 × 20 feet, each plot consisting of six beds 20 feet in length. Two rows of carrots were planted on each bed and irrigated in furrows between the beds. The plots were contiguous, not separated by borders.

D-D was applied at the rate of 100, 200, and 300 pounds per acre with an 18-inch interval between injection points and one dosage at 200 pounds per acre at 12-inch intervals. The chloropicrin was applied at the rate of 200 pounds per acre at a 12-inch interval. The injection points were staggered in rows and the chloropicrin plots were sprinkled with water immediately after treatment. An applicator known as Mack's Fumigant Injector was used to apply both the D-D and the chloropicrin.

The experimental plots were located in the Soledad area in Monterey County. The soil was a light sandy loam of the Hanford series, and was well tilled at the time of treatment, level and free from clods. The soil moisture was 10 to 12 per cent and the soil temperature was 75° F at a 6-inch depth. Chemicals were injected into the soil to a depth of 8 inches. The treatments were made June 3, 1944, and the carrots were planted 6 days afterward.

Population Studies.—Soil samples were taken at random in each plot prior to treatment to determine the distribution of the nematodes. Three samples were taken in each plot; the volume of soil in each sample was 0.07 cubic foot taken from the surface to a depth of 10 inches. These samples were placed in greenhouse pots. Tomatoes were planted in the soil and the number of galls developing on the tomato roots after 6 weeks was taken as an indication of the nematode population.

Similar samples were taken 6 days and 2 months after treatment to deter-

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[50] The author acknowledges the help of S. Dorman, Shell Development Company, and W. H. Lange, Jr., Assistant Entomologist in the Experiment Station.

[51] Associate in the Experiment Station.

mine the reduction in population resulting from the treatments. In table 18 are shown the population counts obtained from the samples.

The data indicate that D-D at the rate of 200 and 300 pounds per acre and chloropicrin at 200 pounds gave significant reductions in the nematode populations as determined by the samples taken 6 days after treatment. D-D at

TABLE 18

AVERAGE NUMBER OF ROOT-KNOT NEMATODE LARVAE PER 0.07 CUBIC FOOT OF SOIL

Material used, rate per acre, and spacing	Before treatment	Six days after treatment	Two months after treatment
D-D; 100 pounds; at 18-inch intervals	36.8	22.00	2.00
D-D, 200 pounds, at 18-inch intervals	32.5	3.70	3.58
D-D; 300 pounds; at 18-inch intervals	36.4	7.18	0.60
D-D; 200 pounds; at 12-inch intervals	45.7	0.41	1.43
Chloropicrin; 200 pounds; at 12-inch intervals	36.8	7.60	6.03
Untreated	46.1	24.90	9.40
Least significant difference	....	±10	±5.5

TABLE 19

AVERAGE NUMBER OF POUNDS OF UNTOPPED CARROTS HARVESTED FROM 100 SQUARE FEET, AND THE CRATES PER ACRE

Material used, rate per acre, and spacing	Average weight of untopped carrots				Calculated number of 90-pound crates per acre
	Total	Marketable	Culls	Nematode infected culls	
D-D; 100 pounds; at 18-inch intervals	80.3	64.9	15.4	4.12	313
D-D; 200 pounds; at 18-inch intervals	77.4	63.6	13.8	2.74	307
D-D; 300 pounds; at 18-inch intervals	69.8	57.4	12.4	2.16	277
D-D; 200 pounds; at 12-inch intervals	72.2	60.8	11.4	1.96	294
Chloropicrin; 200 pounds; at 12-inch intervals	63.3	41.3	22.0	11.10	200
Untreated	24.3	9.25	15.1	7.00	45
Least significant difference	±10.6	±10.0	....	±2.14	....

the rate of 100 pounds per acre does not show effective control, but it is possible that the high population may have resulted from samples taken midway between the points of injection. The population averages 2 months after treatment are shown in table 18. The D-D treatments appeared to be significantly better than no treatment, while chloropicrin was not significantly better. The samples taken 2 months after treatment are of questionable value, since many larvae had entered plants, and in the checks many plants had died as a result of infection.

Yields.—The carrots were harvested October 3, 1944. An area of 100 square feet in the center, or one fourth of each plot, was harvested. The remaining area served as a buffer between treatments. After the carrots were dug they were graded as marketable, culls, and nematode-infected culls. The carrots in each of these classes were then weighed (table 19) and indicate the quality of the carrots grown in each treatment.

The data in table 19 indicate that D-D injected into the soil at the dosage rates and spacing intervals used in this experiment was more effective than chloropicrin as a nematocide, and that increases in yield resulting from the D-D treatments were significantly higher than yields in the chloropicrin-treated and the untreated plots. The total yield and the yield of marketable carrots tend to indicate that the interval between treatment and planting was not long enough to allow the D-D to escape from the soil. If such is the case, it would explain the decrease in yield as the dosage was increased to 300 pounds. D-D applied at 200 pounds per acre at a 12-inch interval indicates

Fig. 13.—The light area in the center shows the poor stand obtained in an untreated plot, as compared with the surrounding treated area.

better nematode control than was obtained with other D-D treatments, although the differences are not significant. The number of crates of marketable carrots shown in table 19 was calculated on an acre basis. The yields resulting from the D-D treatments are approximately six times the yield of the untreated plots while that for chloropicrin was only four times.

The growth and stand of carrots in treated and untreated plots are shown in figure 13, while figure 14 shows the yield of carrots obtained from D-D treated and untreated plots.

Conclusions.—D-D applied at 100, 200, and 300 pounds and chloropicrin at 200 pounds per acre greatly increased the yield of carrots in this experiment. Stand and subsequent growth were significantly better than in untreated plots. The increase in yield was sufficient to convert a net loss to the grower to a fair profit.

There are trends in the yield data which indicate that the interval between treatment and planting was not long enough to allow complete diffusion of the D-D from the soil.

D-D applied at 200 pounds per acre at a 12-inch interval was the most effective treatment in reducing soil populations of the root-knot nematode, as indicated by population samples and the pounds of nematode-infested culls.

D-D was more effective as a nematocide than chloropicrin under the conditions of this experiment.

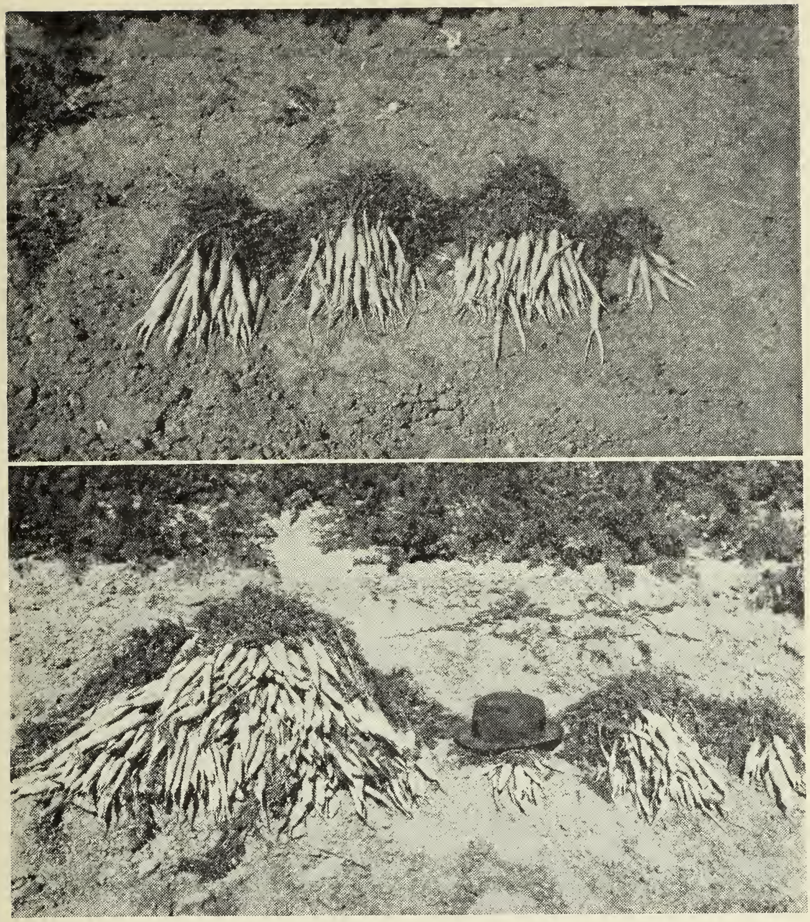

Fig. 14.—Yields of various grades of carrots. Upper: untreated; lower: treated with D-D at the rate of 200 pounds per acre at 18-inch intervals. Left to right: marketable, nematode-infected culls, culls, and insect-injured carrots.

DDT FOR CONTROL OF THE GRAPE LEAFHOPPER[52]

E. M. STAFFORD[53] AND NORMAN W. FRAZIER[54]

Experiments in 1944 indicated that DDT applied either as vapo-spray or as a dry dust mixed with sulfur was effective against grape leafhopper adults and nymphs. In 1945 further experiments were made with sulfur-DDT dust with the view of combining leafhopper control with mildew control. DDT water suspension sprays and DDT vapo-sprays were also tested.

Experiments with DDT Dusts.—A block of Emperor grapes near Woodlake, Tulare County, was divided into plots of from 8 to 10 rows each. Some of the rows were longer than others but each of the plots was about 1.5 acres. One plot received only one application (May 8) of a dust containing 3 per cent DDT; a second plot received two applications (May 8 and June 22) of a 3 per cent DDT dust; while a third plot received three applications (May 8, June 22, August 3) of a 3 per cent DDT dust. The above experiment was replicated, using dusts containing 4 per cent and 5 per cent DDT. Another plot was dusted only once with a 5 per cent DDT dust at the time of the second application (June 22), and still another plot was dusted only once with a 5 per cent DDT dust at the time of the third application (August 3).

The dusts contained 50 per cent dusting sulfur, plus the DDT, and sufficient inert diluent to make the 100 per cent by weight. A regular vineyard power duster was used and every middle was traversed. The prepared dusts were slightly damp and did not flow freely through the dusting machine. Dust in bags which had been opened, dried during the interval between dust applications and flowed through the duster much more freely than the dust of the same composition stored in unopened bags. This caused a variation in dosage at the time of the second and third dust applications. On May 8 all the dusts were applied at the rate of 15.6 pounds per acre. On June 22, dusts containing 3 and 4 per cent DDT were used at the rate of 25 pounds per acre, while the 5 per cent DDT dust was applied at the rate of 15.8 to 17.8 pounds per acre. On August 3, the 3 per cent DDT dust was applied at 21.3, the 4 per cent DDT dust at 14.7, and the 5 per cent DDT dust at 20.3 pounds per acre.

Pretreatment and posttreatment counts of overwintered adults were made on May 7 and 12 respectively. After spreading a canvas under the vine to catch the leafhoppers, individual vines were sprayed with a hand-operated fly-spray atomizer containing pyrethrum in oil to inactivate the leafhoppers. The vines were then shaken and the leafhoppers counted. Counts were made under three vines in each plot. At intervals thereafter counts were made of live adults and nymphs on basal leaves selected at random. A great deal of care was necessary in counting adults on leaves. This was most easily done during the cool hours of the morning when the adults were least active. Nymphs were counted by picking the leaves and examining them closely.

Results with Dusts.—Population counts of overwintering adult grape leafhoppers before and after treatment are given in table 20. In table 21, popula-

[52] The writers wish to express their appreciation to A. E. Michelbacher and Clark Swanson for the help rendered in conducting these investigations.

[53] Assistant Entomologist in the Experiment Station.

[54] Junior Entomologist in the Experiment Station.

tion trends of the grape leafhopper nymphs in the experimental plots at Woodlake are given.

There was little difference in amount of control of overwintered adults resulting from the 4 per cent and the 5 per cent DDT dust (table 20). The 3 per cent DDT dust was much less effective. This was also shown in the population trends of nymphs during the summer (table 21). The poorer control of the 3 per cent DDT dust was manifested not so much by the counts made soon after the dust applications as by the more rapid increase in leafhoppers in the 3 per cent DDT plots than in the 4 or 5 per cent DDT plots. It has been repeatedly observed that the live nymphs found on DDT-treated vines were very young. Often they showed symptoms of DDT poisoning and were not expected to live for more than a few days.

TABLE 20

COUNTS OF OVERWINTERED ADULT GRAPE LEAFHOPPERS

Treatment	Average number of adults per vine	
	Before treatment (May 7)	After treatment (May 12)
Untreated	51.0	50.0
3 per cent DDT	91.8	11.4
4 per cent DDT	121.8	4.0
5 per cent DDT	110.1	2.4

The greatest number of nymphs per leaf occurred early in the season when the amount of foliage was least. Even though the total leafhopper population increased as the season progressed, the increase in amount of foliage greatly reduced the number of leafhoppers per leaf. On vines dusted on May 8 or June 22 a definite peak of nymphs occurred in early September. This peak was not evident on vines receiving the August 3 application of DDT dust. Nearly all plots not receiving an August 3 application showed a marked increase in nymphs in early September. Differences between treatments were partially obscured by the abundant egg parasitism which occurred in the latter part of the season and also by the slight drift of dust during application.

The numbers of adults counted on the leaves were generally less than the numbers of nymphs, except for the counts made on October 2. The relative number of adults observed in the various plots followed very closely the relative numbers of nymphs. This was especially true of observations made soon after the plots were dusted.

Data on residues will be found in the report on deposits and residues (table 36, p. 105).

Experiments with DDT Vapo-Spray.—On May 12 and 13, contiguous 20-acre blocks of Emperor and Ribier variety grapes on the same ranch were treated with a proprietary vapo-spray oil containing 1.2 per cent DDT at a rate of 4.7 gallons per acre. The application was made by a commercial operator, the machine traversing every middle so that each vine row was sprayed on both sides. Pretreatment samples were not taken, but beginning with post-

TABLE 21

TRENDS IN POPULATIONS OF GRAPE LEAFHOPPER NYMPHS IN DUSTED PLOTS AT WOODLAKE, 1945

Concentration of DDT in dust, May 8	Average number of nymphs per leaf on the dates indicated				Concentration of DDT in dust, June 22	Average number of nymphs per leaf on the dates indicated			Concentration of DDT in dust, August 3	Average number of nymphs per leaf on the dates indicated		
	May 12	May 22	June 6	June 21		June 24	July 13	August 1		August 6	Sept. 4	October 2
None	25.2	23.8	66.8	29.4	None	26.7	17.1	41.9	5 per cent	0.2	0.0	0.0
None	7.7	12.9	45.3	24.1	5 per cent	0.3	1.5	2.5	None	3.1	22.1	3.6
3 per cent	0.0	0.6	10.7	10.1	3 per cent	0.0	0.7	9.5	None	7.6	23.1	1.7
3 per cent	0.1	0.8	8.3	4.6	3 per cent	0.0	0.1	3.1	3 per cent	0.6	5.6	0.1
3 per cent	0.0	0.4	0.4	0.8	None	0.7	3.5	8.4	None	11.0	19.2	0.6
4 per cent	0.0	0.5	1.7	4.5	4 per cent	0.1	0.0	4.0	None	4.4	4.9	0.6
4 per cent	0.0	0.7	3.7	0.4	4 per cent	0.2	0.0	1.1	4 per cent	0.3	1.0	0.1
4 per cent	0.0	0.8	3.8	0.2	None	0.6	2.9	9.5	None	8.9	11.5	3.0
5 per cent	0.0	0.3	1.0	0.4	5 per cent	0.0	0.2	4.5	None	4.0	8.4	1.3
5 per cent	0.0	1.1	2.8	1.4	5 per cent	0.0	0.3	2.6	5 per cent	0.4	1.7	1.1
5 per cent	0.0	1.4	3.3	1.6	None	1.8	1.3	5.5	None	4.3	6.0	0.3

treatment samplings, counts were made of live adults and nymphs in four blocks on approximately the same dates and in like manner as described for the dusted plots. Some of the data are contained in table 22.

The trends of nymphal populations were comparable between the dust-treated and vapo-sprayed plots. Both methods of DDT application in early spring yielded comparable results since there appeared to have been little difference between the plots dusted once on May 8 (table 21) and those vapo-sprayed once on May 12 or 13 (table 22) so far as subsequent build-up of nymphal population is concerned. Although on September 4 some rather wide variations existed in the average number of nymphs per leaf between the several plots treated only during May either with dust or vapo-spray, it is

TABLE 22

TRENDS IN POPULATIONS OF GRAPE LEAFHOPPER NYMPHS IN VAPO-SPRAYED BLOCKS AT WOODLAKE

Grape variety	Average number of nymphs per leaf on sampling dates*							
	May 19	May 26	June 11	June 27	July 13	Aug. 1	Sept. 4	Oct. 2
Emperor	0.2	3.0	1.9	0.1	4.4	8.9	11.5	0.0
Emperor	...	...	0.2	0.0	6.9	3.0	25.9	0.1
Emperor	...	...	7.8	0.0	1.7	4.5	7.9	0.6
Ribier	0.5	1.7	5.6	0.0	1.3	13.5	7.8	0.0

* Vapo-spray applied May 12 and May 13.

probable that these differences were not due to treatment alone. In June, migration of adult leafhoppers into the vineyards caused such a large increase in the population around the perimeter of the treated area that additional control became necessary during August in marginal portions of several blocks. Because of this fact, location of the plots and location of the vines sampled within each plot were important factors. Samplings of vapo-sprayed blocks were taken in the interior of the block where the effects of the migration were largely absent; whereas, in the dusted plot, because of their position and smaller size it was not possible to mitigate these effects to any comparable extent.

By the first week in July, damage by the Willamette mite, though light, was more apparent on DDT-treated plots than on the untreated plot. There was no apparent difference, however, by September.

Experiment with DDT Water Suspension Spray.—On May 10 a spray containing 4 pounds of 20 per cent DDT wettable powder and one gallon of kerosene per 100 gallons of water was applied to Zante grapes at Madera. Each vine received approximately 0.4 gallon of spray. This spray gave excellent control of both adults and nymphs of the grape leafhopper and the residue on the leaves continued to show effective control until late June.

Experiments on Grapes at Lodi.—On May 16 a block of Alicante grapes at Lodi was divided into three plots one of which received a vapo-spray treatment of proprietary vapo-spray oil containing 1.2 per cent DDT at the rate of 3.75 gallons per acre. Another plot received no DDT treatment, while a third plot was dusted with a 3 per cent DDT dust (containing no sulfur) at the rate

of 22.1 pounds per acre. After 6 days the DDT treatments showed marked reductions of both overwintered adults and nymphs; the vapo-spray treatment was much more effective. This vineyard had shown damage from Pacific mite in previous years. Late in the 1945 season there was no noticeable difference between the DDT-treated plots and the untreated plot in amount of Pacific mite damage.

Conclusions.—In these trials, DDT applied in early May as a dust with sulfur, or as a vapo-spray or a water suspension spray, gave control of grape leafhopper adults and nymphs. Dusts of 4 or 5 per cent DDT at 20 pounds per acre were more effective than a 3 per cent DDT dust applied at the same rate. DDT dust also gave control of the grape leafhopper when applied in June or early August. It will not be possible, however, to use DDT commercially after the fruit is set until more has been learned of the persistence of DDT residue on grapes. There is also some indication that the use of DDT for grape-leafhopper control may favor the increase in Willamette mite populations.

This investigation has indicated that a treatment just before bloom of a sulfur dust containing 5 per cent DDT at 20 pounds per acre or an oil vapo-spray containing 1.2 per cent DDT at 3 to 5 gallons per acre should control grape leafhoppers for the entire season, provided that the application gives complete coverage of the vines and that there is no reinfestation from adjacent areas.

DDT residue determinations on grapes from different treatments were made on two occasions late in the season. Grapes collected on August 24 were analyzed by a modified Gunther method and the results will be found in table 35 (p. 102). Grapes collected on September 13 were analyzed by a colorimetric method and the data will be found in table 36 (p. 105). Where vines were dusted as late as May 8, the DDT residue was very low approximately 5 weeks before harvest.

CONTROL OF THRIPS ON GRAPES WITH DDT

A. E. MICHELBACHER[55] AND CLARK SWANSON[56]

Thrips have been found to be very important in causing the failure of grapes to set fruit in several vineyards near Escalon, San Joaquin County. The damage apparently occurs during the blooming period and may result in a partial to complete shedding of the blossoms or the very young fruit in a cluster. A serious attack results in a substantial loss to the grower.

Thrips populations were determined by jarring flower clusters over a cardboard and counting the thrips that dropped on it. On untreated vines in one vineyard an average of 4.3 thrips was collected by this method on May 15. By May 22 the number rose to 7.2, but dropped to 4 on June 1. An average of 18 per cluster was collected on June 12. The thrips involved were determined by H. H. Keifer of the California State Department of Agriculture as *Frankliniella moultoni*; its variety, *occidentalis; Thrips tabaci;* and a less common type which he tentatively determined as *Anaphothrips* sp. Portions of the vineyard were dusted from May 18 to May 20 with mixtures that contained 2 to 4 per cent DDT. Some of the treatments resulted in a very good kill of thrips, but the residual action appeared to be of rather short duration, and the clusters soon became heavily reinfested. The crop suffered severe injury, and at harvest no visual difference could be detected between treated and untreated plots.

Another heavily infested vineyard was dusted on June 8 with a 3 per cent DDT dust at from 15 to 30 pounds per acre. The material was applied with a regular grape duster to both sides of the row. The treatment resulted in a good kill of thrips. Although considerable thrips damage had occurred before the dust was applied, some benefit was obtained, for at harvest it was evident that the treated area outyielded the check.

Conclusions.—Under certain conditions thrips may cause a severe dropping of blossoms and very young fruits. Based on one year's observations, it appears that most of the damage is done between May 15 and June 20. DDT dusts were found to be effective in controlling the thrips but the exact concentration, dosage, and frequency of application necessary to give satisfactory control remain to be determined.

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CONTROL OF CODLING MOTH AND PEAR THRIPS ON PEARS, AND CANKERWORMS AND GREEN FRUIT WORM ON APRICOTS

A. D. BORDEN[57]

Reported here are a number of experiments on the control of certain deciduous fruit insects. The tests were conducted primarily to determine the efficiency of DDT against these pests. In some of these experiments this insecticide was compared with standard treatments.

CONTROL OF CODLING MOTH ON PEARS

Bartlett Pears.—A plot of 106 twenty-five-year-old Bartlett pear trees in an orchard where the fruit in 1944 had been very wormy was selected for a DDT spray control test. The remainder of the orchard received the regular standard lead arsenate treatment. All applications were made with grower equipment consisting of a speed sprayer drawn by a tractor. Two different DDT spray programs were tested. In one program, 62 trees (treatment A) received a DDT calyx spray and three DDT cover sprays, while in the second program, 44 trees (treatment B) received a standard lead arsenate calyx spray and three DDT cover sprays similar to those applied to treatment A. The DDT calyx spray contained 5 pounds of 20 per cent DDT wettable powder and 5 pounds of wettable sulfur per 100 gallons of water. The first DDT cover spray consisted of 5 pounds of 20 per cent DDT wettable powder, 1 pound DDT depositor, and 1 quart of kerosene per 100 gallons of water. In the last two cover sprays the amount of DDT wettable powder was reduced to 2½ pounds per 100 gallons of water. The standard lead calyx spray used for treatment B contained 4 pounds standard lead arsenate, spreader, and 5 pounds wettable sulfur per 100 gallons of spray. The remainder of the orchard (treatment C) received this calyx spray and four standard lead arsenate cover sprays. The composition of the spray for the first two cover sprays was 4 pounds standard lead arsenate, spreader, and 2 quarts of summer oil emulsion per 100 gallons. In each of the last two cover sprays the amount of lead arsenate was reduced to 3 pounds. The DDT cover sprays were applied April 21, May 10, May 29, and June 29. The standard lead arsenate treatments were applied April 21, May 10, May 29, June 16, and July 17. The fruit was harvested according to size July 12, July 26, and August 11. Fruit counts were made at each picking from at least 10 trees in each plot. Harvest information is given in table 23.

Though the two-spotted mite, *Tetranychus bimaculatus* Harvey, did slight damage to the foliage in the late season in this orchard, it was not observed to be more injurious in the DDT plots than elsewhere in the orchard.

Hardy and Bartlett Pears.—An orchard of seventy-five-year-old Hardy pears, consisting of 360 trees, interset every third row with Bartlett pears, was divided into two equal areas. Both of these received two calyx sprays of 4 pounds of standard lead arsenate plus spreader per 100 gallons of water. To one area (treatment A) two cover sprays of 4 pounds of standard lead arsenate, spreader, and 2 quarts of summer oil emulsion per 100 gallons of

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water were applied. To the second area (treatment B) two cover sprays that contained 4 pounds of 25 per cent DDT wettable powder, 1 pound DDT depositor, and 1 quart kerosene per 100 gallons of water, were applied. The first cover spray in both areas was applied on May 22 and the second on June 29. All spraying was done with ground portable equipment using orchard guns.

TABLE 23

COMPARISON OF STANDARD LEAD ARSENATE AND DDT FOR CONTROLLING CODLING MOTH ON PEARS

Treatment	Date picked	Worms per 100 fruits		Total fruit counted (including windfalls)
		Windfalls	Picked fruit	
Treatment A: Three DDT calyx sprays and three cover sprays	July 12	0.0	0.0	948
	July 26	0.0	0.0	1,819
	August 11	1.2	0.1	1,235
Treatment B: Standard lead arsenate calyx spray and three DDT cover sprays	July 12	0.0	0.0	951
	July 26	0.2	0.1	1,629
	August 11	0.2	0.5	1,486
Treatment C: Standard lead arsenate calyx spray and four cover sprays	July 12	6.3	0.6	2,065
	July 26	4.8	2.8	2,002
	August 11	21.7	6.1	2,226

TABLE 24

COMPARISON OF STANDARD LEAD ARSENATE AND DDT IN COVER SPRAYS FOR CONTROLLING CODLING MOTH ON PEARS

Treatment	Worms per 100 fruits of Hardy pears			Worms per 100 fruits of Bartlett pears		
	Windfalls	Picked fruit	Total counted (including windfalls)	Windfalls	Picked fruit	Total counted (including windfalls)
Treatment A: Standard lead arsenate in two calyx sprays and in two cover sprays	12.0	10.7	1,349	8.0	7.6	1,695
Treatment B: Standard lead arsenate in two calyx sprays and DDT in two cover sprays	2.0	3.7*	1,693	6.0	2.8*	2,385

* Practically all dry stings without live worms.

Fruit counts were made on July 24 and 25, and on August 7 and 8. These are summarized in table 24.

The almond mite, *Bryobia praetiosa* Koch, and Baker mealybug, *Pseudococcus bakeri* (Essig) built up high populations in the DDT plot but not in the arsenate plot.

CONTROL OF ADULT PEAR THRIPS ON OPENING BUDS OF PEAR AND PRUNE TREES

In 1945, three experimental plots were laid out in Santa Clara County and spray and dust treatments made in an attempt to control adult pear thrips before damage occurred to the opening buds. Pears and prunes were treated

with 5 per cent DDT in mineral seal oil at a dosage of 1 pound actual DDT per 100 gallons during the swollen bud stage. An equal number of trees were sprayed with 5 pounds of 20 per cent wettable DDT powder. The third plot received a heavy application of a 5 per cent DDT dust applied to the ground under each tree. Thrips emergence traps were placed in each plot and daily records taken. The treatments were applied February 16; on March 7, when the buds were still in the tight cluster stage, only an average of 2 thrips in 100 buds were found in the sprayed trees, while unsprayed trees and dusted plot showed an average of 10 thrips per 100 buds. On March 22 the buds were approaching the open cluster stage and no thrips had been taken in the traps. The sprayed trees showed an average of 1 thrips per 10 buds and the check, 2 thrips per 10 buds. Following this inspection, the fruit buds opened very rapidly; thus the flower opening occurred ahead of the thrips emergence.

In a similar experiment in Solano County, 135 pear trees were treated February 22. On March 6 the counts showed an average of 8 thrips per 100 buds on sprayed trees and an average of 32 thrips per 100 buds in the check. On March 21 the buds were in open cluster with white petals showing and the counts were averaging 10 per 100 buds on sprayed trees and 30 per 100 on check trees and trees in the dusted plot. In an adjoining untreated prune orchard, the trees were 50 per cent in full bloom and the thrips were very numerous. Evidently because of the more advanced stage of these trees the thrips showed preference for them.

In Contra Costa County three small orchards were kept under observation and a part of one was sprayed with 5 per cent DDT in mineral seal oil at a dosage of 1 pound actual DDT per 100 gallons. Thrips traps and soil thermometers were checked daily by the owner. Soil temperatures were under 50°F until after the fruit buds had passed the cluster period and no appreciable number of thrips was found in the buds. No thrips were taken in the traps until the soil temperature had reached 54°F and then regular daily catches were obtained.

No bleeding of swollen fruit buds or darkening of the flowers occurred in any of these orchards this season. The soil temperatures were too low for adult thrips emergence until after the buds had opened. Under these conditions only a slight indication of the value of the DDT treatment could be shown but the results were promising enough to justify further trials in another season.

CONTROL OF PEAR THRIPS LARVAE ON BARTLETT PEARS

A large block of thirty-five-year-old Bartlett pear trees was sprayed on March 24 by the grower's crew; a stationary spray system was used, with 12-foot single nozzle spray rods. Two population determinations of thrips larvae were made: the first, just prior to spraying, by making counts of thrips in 10 fruit clusters per tree and from 10 trees in each spray block; and the second, 5 days after the spray application. The prespray counts showed an average of from 34 to 98 thrips per 10 clusters, and the postspray counts showed an average of from 0 to 5 larvae per 10 clusters. Clusters from trees sprayed with lead arsenate, adjacent to the DDT sprayed trees, showed an average of from 15 to 35 larvae per 10 clusters.

In the applications, five 600-gallon tanks of spray were applied. The 25 per cent DDT wettable powder, at 5 pounds per 100 gallons of water, was used, and the spreader combinations in each tank were varied. The composition of the spray mixtures per 100 gallons of water, and the degree of wetting obtained are given in table 25.

TABLE 25

Type of Wetting Obtained with Different Wetting Agents

Tank no.	Depositor or spreader	Emulsive oil	Flocculation in tank	Type of wetting
1	0	1 quart	None	Very poor, beaded on foliage
2	1 pound DDT depositor	1 quart	Fair*	Good
3	½ pound DDT depositor	2 quarts	Small	Poor
4	4 ounces blood albumin	1 quart	None	Poor
5	8 ounces blood albumin	1 quart	None	Fair

* Light scum on surface of liquid in tank.

CONTROL OF CANKERWORMS AND GREEN FRUIT WORM ON APRICOTS

The larvae of cankerworms and a green fruit worm (*Orthosia* sp.) caused severe injury to apricot fruit in the Brentwood area in 1944. On March 24, 1945, in an orchard of Blenheim variety both liquid and dust applications were made to effect a control. The spray was applied with a speed sprayer at dosages of ½ and 1 pound actual DDT per 100 gallons of water. On March 28, careful inspection over the sprayed area showed no living larvae of either species of insect, while in the untreated areas there were many larvae and considerable foliage damage. This application, made in the jacket period of fruit development, was so effective that no insect damage to fruit was noted at harvest.

On March 27, part of an adjoining orchard was dusted with a 5 per cent DDT dust and the remainder of the orchard with 50 per cent cryolite dust at an approximate dosage of 50 pounds per acre. A single-nozzle drift-type orchard duster was used. Inspection of the orchard on March 28 showed no larvae present on the DDT plot, while an occasional live larvae could be found in the cryolite plot. Observations have shown that cryolite dusts are much slower than DDT or pyrethrum in killing cankerworm larvae.

SUMMARY

Sprays containing DDT wettable powder were found to be much more effective in controlling codling moth on Bartlett and Hardy pears than was the regular standard lead arsenate program. In one Bartlett pear orchard a standard lead arsenate calyx spray, followed by three DDT cover sprays, and a program involving DDT in the calyx spray, followed by three cover sprays, both resulted in excellent control. In the calyx and first cover spray, 1 pound of actual DDT was used per 100 gallons, while in the last two cover sprays the amount was reduced to ½ pound. In another orchard planted to Bartlett and Hardy pears, excellent control was obtained where standard lead arse-

nate was used in the calyx and the first cover sprays, followed by DDT used at the rate of 1 pound of actual material per 100 gallons in the last two cover sprays. In this orchard, where the trees were treated with DDT, a marked increase occurred in the almond mite and Baker mealybug population.

Because of late emergence, inconclusive results for the control of adult pear thrips were obtained with DDT sprays and dusts applied to pear trees during the swollen bud stage.

Good control of pear thrips was obtained with DDT sprays applied during the cluster stage of bloom on Bartlett pears.

A spray containing ½ pound of actual DDT per 100 gallons of water, or a 5 per cent DDT dust, was very effective in controlling the larvae of cankerworms and green fruit-worm on apricot.

OBSERVATIONS ON APHID CONTROL BY DDT VAPOR FOG AND WATER SUSPENSION SPRAY

E. O. ESSIG[58]

A demonstration of the United States Army smoke machine at Emeryville, California, on May 22, 1945, was conducted by the manufacturers to test DDT as a vapor, or fog, for the control of such insects as were available at that time and place. This very compact and beautifully constructed machine, weighing only about 150 pounds, was adapted for the application of insecticides as fogs, or vapors, by Professor Victor K. LaMer and Dr. Seymore Hochberg of Columbia University.

The demonstration was conducted near the Bay Shore Highway and the fog was directed eastwardly with the prevailing westerly winds. The winds carried the fog a great distance, so that it was visible for at least 500 feet or more.

The DDT was applied both at 5 per cent in oil, and at 30 per cent in oil, in periods of 12 and 14 minutes each; there were two periods of 12 minutes and two periods of 14 minutes, in which the full force of the fog was directed along the ground as indicated above. For the purpose of checking the effects of the vapor, blowflies were exposed in screened cages and found to be killed at distances up to 200 yards. There were present, however, in the direct path of the fog some native plants which were infested with aphids and these plants were carefully observed by the writer who noted the following results:

The common sowthistle, *Sonchus oleraceus* L., was growing in considerable quantity and was very heavily infested with the sowthistle aphid, *Amphorophora sonchi* (Oestlund). During the application of the fog, the specimens, which were subsequently taken to the laboratory and observed over a period of 2 weeks, were given the full quadruple dosages of the DDT fog, that is, a 5 per cent and 30 per cent DDT in oil for 12 minutes, and like dosages for 14 minutes. The fog was applied in a forceful, constant, direct line, and the infested plants were growing in a position where they were fully exposed to the application.

From the very beginning of the applications, the aphids showed little or

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no effects and it was noted that none of them appeared uncomfortable. Since the day was cloudy and cold, the specimens taken to the laboratory arrived fresh and in good condition. The plants were placed in water and continued to remain perfectly fresh and normal in appearance. During the first day, a few aphids moved around on the plants and 12 dead ones were noted clinging to the hosts. These colonies were examined daily for a period of 2 weeks, and, while a number of dead ones appeared, the colonies in general developed normally and increased in such numbers, that the material was discarded after a period of 2 weeks. The young developed normally and it appeared that less than 1 per cent of the members perished during the interim.

Growing along with the sowthistle plants were a number of wild radish plants, *Raphanus sativus* L., which were heavily infested with the cabbage aphid, *Brevicoryne brassicae* Linn. A few minutes after the DDT fog was directed on these colonies, the aphids showed distinct uneasiness and began to move about. Many of them died, while others perished before withdrawing their mouth parts. Infested plants of these were likewise taken to the laboratory and kept in water, where the radishes continued to remain fresh for some time. Before the end of the first day, May 22, an estimated 40 per cent of the aphids were dead, while the remaining 60 per cent appeared to be in perfectly good condition. In a few instances, the plants began to wilt a little but recovered during the succeeding night. By May 28 the colonies had become stabilized, and the young were casting their skins and maturing in the normal manner. As a matter of fact, they were becoming crowded. At this time, however, the older plants were dying, so fresh uninfested plants of wild radish were brought in and placed alongside of them. The aphids moved over to the new plants and multiplied in great numbers—so much so, that it was necessary to dispose of the plants 2 days thereafter. This transfer eliminated the residual effects of the DDT on the original hosts and terminated the experiment.

From this experiment, it would appear that the cabbage aphid is mildly susceptible to DDT fog.

Another test on resistance of the sowthistle aphid to DDT was made in a backyard in the treatment of an apple tree for codling moth control. The DDT was applied as a spray consisting of a wettable powder suspended in water. The concentration was 20 per cent DDT wettable powder, at the rate of 5 pounds per 100 gallons, and 20 gallons were applied at each application. The first application was made on June 8, and the second application made on June 30. Both applications were greatly in excess of the amount necessary for full coverage. Growing directly under this apple tree, and receiving great quantities of the spray, were 2 plants of the common sowthistle, heavily infested with the sowthistle aphid. These plants were not molested, except to be examined for aphid infestation. The colonies of aphids seemed not at all disturbed by the spray; in fact, not a single individual was observed to have been killed over a period of 3 weeks.

The tree sprayed was one of four in the yard. Three of these had been regularly heavily infested (up to 50 per cent) with codling moth and only one, a Golden Delicious, had remained practically free of this pest throughout a period of twenty years. Up until 1945, these trees had never been sprayed.

In 1945 the Golden Delicious was selected for trial with DDT. The first

application was made on June 8, and the second three weeks later, June 30. During the remainder of the season red spiders, European red mites, and two-spotted mites increased as they had never increased before on this tree. The leaves turned brown and many of them fell off, but not enough to denude the tree seriously. The apples remained practically free from codling moth for the first time, but the fruit never sized up. In fact, most of the apples were only about one half normal size. The fruit was also practically tasteless, so much so that it was absolutely unfit to eat. Whether these effects on the fruit were caused by the attacks of the mites or by an overdose of DDT has not been determined.

CONTROL OF CODLING MOTH ON PAYNE VARIETY OF WALNUT[59]

A. E. MICHELBACHER,[60] CLARK SWANSON,[61] AND O. G. BACON[62]

Investigations on the control of codling moth attacking walnuts have been under way in the Linden area since 1941. The results of these studies up to and including 1944 have been reported on by Michelbacher.[63] These results showed two principal broods of moths that must be controlled. The peak of the first brood usually occurs in late April or early May and that of the second in July. To insure best control, two sprays are necessary. The timing of the first spray is of greatest importance because of the rapid build-up of the first brood of caterpillars. The first spray should be applied about the first of May and the second, the latter part of the month, although it can be applied with rather good results any time up to about the end of June. The principal materials used in the earlier work were basic lead arsenate and standard lead arsenate with a safener, although in 1944 some investigational work with DDT was initiated.

Investigations in 1945.—The following materials were included in the investigations: basic lead arsenate, standard lead arsenate, DDT, trichloro-chloro-phenyl-phenyl-ethane, and a new synthetic organic stomach poison known as HE 761. They were used in the following treatments:

1. Check.
2. Two sprays basic lead arsenate, May 3 and 31.
3. One spray standard lead arsenate with safener, May 3.
4. Two sprays standard lead arsenate with safener, May 3 and 31.
5. One spray DDT (1 pound per 100 gallons of water), May 4.
6. Two sprays DDT (1 pound per 100 gallons of water), May 4 and 31.
7. One spray DDT (½ pound per 100 gallons of water), May 4, and one spray standard lead with safener, May 31.

[59] Thanks are due to C. C. Anderson and Ralph Bishop, who made possible the investigations on codling moth at Linden.

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[62] Associate in the Experiment Station.

[63] Michelbacher, A. E. Control of codling moth on walnuts: progress report. Jour. Econ. Ent. 38(3):347–55, 1945.

8. One spray trichloro-chloro-phenyl-phenyl-ethane (1 pound per 100 gallons of water), May 31.
9. One spray HE 761, May 4.
10. Two sprays HE 761, May 4 and 31.

The experiment was conducted on plots of 1 tree each. Treatments 1 to 7 inclusive were replicated seven times in a Latin square. Treatment 8 was replicated five times, and treatments 9 and 10, four times each. Besides these tests, treatments 2, 3, 4, 5, and 6 were applied to blocks of 56 trees each, on an experimental commercial scale.

The composition of the different spray mixtures, per 100 gallons, were as follows:

BASIC LEAD ARSENATE SPRAY

Basic lead arsenate	4 pounds
Wetting agent	⅛ pound
Medium emulsive oil	⅛ gallon

Order of mixing: Oil when tank was one fourth full, followed by spreader as water was being added, and then the lead arsenate.

STANDARD LEAD ARSENATE SPRAY

Standard lead arsenate	3 pounds
Safener, commercial basic zinc sulfate product containing 50 per cent zinc expressed as metallic	1 pound
Liquid adhesive	½ pint
Medium emulsive oil	⅛ gallon

Order of mixing: Standard lead arsenate and safener slurried and added when tank was one fourth full, followed by liquid adhesive, and oil added when tank was approximately two thirds to three fourths full.

DDT SPRAY

20 per cent wettable DDT powder	5 pounds
Depositor	⅛ pound, first spray; ½ pound, second spray
Light medium oil emulsion	1 quart

Order of mixing: DDT added when water was up to agitator rod, then depositor, followed by the oil.

TRICHLORO-CHLORO-PHENYL-PHENYL-ETHANE SPRAY

20 per cent wettable trichloro-chloro-phenyl-phenyl-ethane powder	5 pounds
Light medium oil emulsion	1 quart

Order of mixing: Trichloro-chloro-phenyl-phenyl-ethane added when water was up to the agitator rod, followed by the oil emulsion.

HE 761 SPRAY

HE 761	1½ pounds

Material added to tank while being filled.

All sprays were applied, at a pressure of 600 pounds, with sprayers having 25-foot towers, equipped for automatic spraying (fig. 15). Approximately 55 gallons of material were applied per tree for each application.

During the growth of the crop, the trend of the infestation for the different treatments was determined by making ten tree surveys. On each survey, 80

nuts on the lower portion of each tree were examined. The results of these surveys, together with the per cent of infested nuts in the harvested crop, before any sorting, are summarized in table 26. For the first season since the investigation was started, there was no rapid and marked build-up of the first

Fig. 15.—Spray equipment used in the investigation. (Courtesy of C. C. Anderson.)

brood. This is clearly shown in the check plots where, at the peak of the first brood, only 7.85 per cent of the nuts were infested. The small size of the first brood was also reflected by the number of moths captured in the bait pens. The bait pan record is shown in figure 16. Despite the rather small first brood, there was a sizable second brood, which is indicated by the large numbers of moths captured in the bait pans.

Based upon the tree surveys and the amount of infested nuts in the harvested

TABLE 26

PER CENT CODLING MOTH INFESTATION IN WALNUTS AS DETERMINED BY SURVEYS OF GROWING CROP AND PER CENT OF INFESTED NUTS IN THE HARVESTED CROP AT LINDEN, 1945

Treatment and date applied*	Average per cent infested nuts on the survey dates given									Per cent infested nuts in harvested crop
	May 21	June 1	June 12	June 26	July 10	July 24	August 7	August 23	Sept. 5	
Check†	4.64	6.07	7.85	4.46	4.46	6.78	11.78	13.39	16.42	6.77
Basic lead arsenate, May 3 and 31	1.42	1.60	1.42	1.60	1.07	1.07	2.15	3.21	3.92	2.16
Standard lead arsenate, May 3	0.89	0.35	0.53	0.17	0.00	0.53	1.98	2.15	3.21	1.29
Standard lead arsenate, May 3 and 31	0.89	0.00	0.17	0.71	0.53	0.35	0.89	1.07	1.78	0.96
DDT (1 pound per 100 gallons), May 4	0.00	0.00	0.35	0.17	0.00	0.17	1.42	1.42	2.15	0.79
DDT (1 pound per 100 gallons), May 4 and 31	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.13
DDT (½ pound per 100 gallons), May 4; standard lead arsenate, May 31	0.00	0.75	0.00	0.00	0.00	0.00	0.89	0.89	0.71	0.58
Trichloro-chloro-phenyl-phenyl-ethane (1 pound per 100 gallons), May 31	4.64	6.07	3.33	5.00	4.00	7.33	8.00	....	8.20	6.65
HE 761, May 4	0.75	0.75	0.31	0.31	0.25	1.56	2.81	4.25	5.00	1.59
HE 761, May 4 and 31	0.75	0.75	0.93	0.31	0.25	0.31	1.25	0.25	0.50	0.93

* For complete composition of sprays see formulas in the text.
† Infestation of check plot on May 4 was 0.5 per cent.

crop, all treatments, with the exception of trichloro-chloro-phenyl-phenyl-ethane, resulted in rather satisfactory control. Best control was obtained with two applications of DDT, where the DDT was used at the rate of 1 pound to 100 gallons of water. The next best treatment was where the first spray contained ½ pound of actual DDT to 100 gallons of water and the second spray, regular standard lead arsenate with safener. One spray of DDT, used at the rate of 1 pound to 100 gallons, and two sprays of standard lead arsenate with safener gave about equally good control. The two-spray treatment of HE 761 falls in the same category. The two-spray basic lead arsenate treatment failed to equal the control obtained with a single early spray of standard lead arsenate with safener.

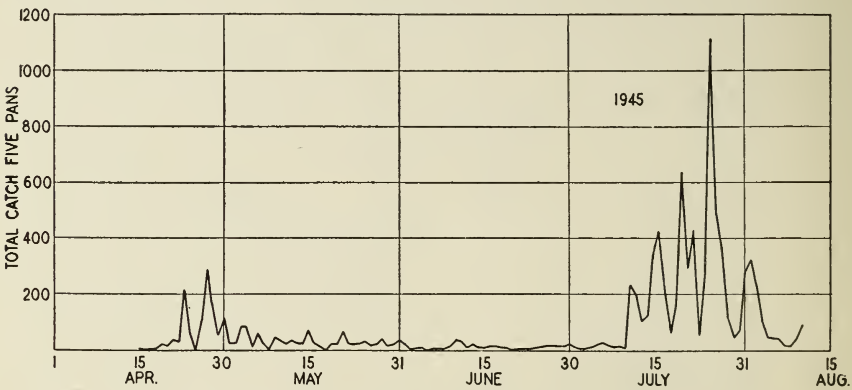

Fig. 16.—Codling moth bait-pan record for 1945.

The information obtained where trees were sprayed on an experimental commercial basis is given in table 27. All the treatments resulted in a satisfactory control of the codling moth. No infested nuts were found where two sprays of DDT were applied. The control obtained with one spray of DDT compared favorably with the two-spray standard lead arsenate treatment. The one-spray standard lead arsenate treatment resulted in better control than two sprays of basic lead arsenate. It was nearly as good as two sprays of standard lead arsenate. The greatest difference between the two treatments was in the fact that there were distinctly more infested nuts in the culls of the one-spray treatment.

There was a marked difference in the yield of sound nuts for the several treatments. It is believed that most of this difference was due to a variation in the productivity of the plots, and in an error in grading the nuts for light color of meat and for soundness, rather than to the difference in treatment.

Observations on the relation of the walnut aphid to the various treatments were made but these are considered under a separate section on the walnut aphid. Here, it will suffice to say that some of the treatments tended to suppress while others tended to favor a build-up of the aphid population.

Conclusions.—Based on the 1945 investigations, it appears that one spray of standard lead arsenate with a safener, applied in early May, was at least as effective as two sprays of basic lead arsenate, with the first applied in early May and the second the end of May. DDT resulted in exceptionally good

control of the codling moth. Where used at the rate of 1 pound of actual DDT to 100 gallons of water, two sprays (May 4 and May 31) resulted in only 0.13 of 1 per cent of the harvested nuts in the plot area being infested. Where the same treatment was applied on an experimental commercial basis, no infested nuts were found in a cracking test of 600 nuts. One spray of DDT in the plot area reduced the infestation in the harvested crop to 0.79 of 1 per cent, and in the commercial experimental block to a little more than 1 per cent. Both the one- and two-spray treatments caused some build-up of a mite population which was most severe where two sprays were applied. By harvest time there was some defoliation, but this occurred so late in the season that no harmful effect on the crop could be detected. However, the orchard had received excellent care and it is very possible that serious injury might have resulted had the investigational work been conducted in an orchard that had been allowed to suffer from lack of water or from some other cause.

Very satisfactory control was obtained where a spray containing ½ pound of DDT to 100 gallons of water was applied on May 4, followed by a standard lead arsenate spray with safener on May 31. Where this combination was used there was no evidence of a build-up in the mite population. Further, this treatment ranked next to two sprays of DDT in controlling the codling moth, and is certainly a program that warrants further study. It may offer a means of using DDT without seriously upsetting the balance of nature. Spray program investigations that involve a reduction of both DDT and lead arsenate are planned for the following year.

Since this investigation was started in 1941, there has been a year-to-year decline in the infestation of nuts in the orchard where the studies have been conducted. For the check plots, the trend in the harvested crop has been as follows: 1942, 24.07 per cent; 1943, 18.73 per cent; 1944, 13.19 per cent; and 1945, 6.77 per cent. This condition appears to have been general for nearly the entire Linden area. Whether the decline has been due to natural conditions, or to an improved spray program in the district, or both, is not known. However, if the situation remains at, or near, the present level, it would appear that a single early thoroughly applied spray should adequately control the infestation. This certainly appears to be the case if DDT or standard lead arsenate with a safener can be successfully used. The control obtained by a single early application with either of these materials is so good, that the slight additional benefit obtained from a second spray hardly appears to justify the cost.

To the present time, no tree injury from standard lead arsenate has been observed. However, before unrestricted recommendations for its use can be made, further experimental commercial tests should be made. It will be most desirable to have a number of growers apply the treatment to a portion of their holdings during the 1946 season.

The control obtained with DDT has been very outstanding. However, before it can be generally recommended, further experimental testing is necessary. Investigational work has proceeded to a point where testing on a commercial experimental basis is desirable. When used alone—not in combination with other materials—the actual amount of DDT per 100 gallons of spray should not exceed 1 pound.

TABLE 27

HARVEST DATA FROM PLOTS SPRAYED ON A COMMERCIAL EXPERIMENTAL SCALE

Treatment*	Quality of nuts after first culling†						First culls	
	Per cent of light-colored meats	Per cent of sound nuts	Per cent wormy	Estimated per cent of culls removed by processing‡	Total weight of nuts (pounds)	Total sound nuts (pounds)	Total pounds	Per cent wormy§
Basic lead arsenate, two sprays	50.2	85.2	1.6	7.6	7,439	6,338	465	13
Standard lead arsenate, one spray	52.0	82.6	1.2	12.2	7,371	6,089	245	5
Standard lead arsenate, two sprays	52.0	82.6	1.0	9.8	7,987	6,598	430	1
DDT, one spray	55.4	85.2	1.2	9.2	9,011	7,678	333	1
DDT, two sprays	46.8	89.2	0.0	5.4	7,259	6,475	399	0

* For complete composition of sprays see formulas in the text.
† Based on a cracking test of 500 nuts.
‡ This column represents shrivels, sunburned, severely infested, blighted nuts, and other culls.
§ Based on a cracking test of 100 nuts.

CONTROL OF CATALINA CHERRY MOTH ON WALNUTS

O. G. BACON,[64] A. E. MICHELBACHER,[65] AND GORDON L. SMITH[66]

Investigations conducted in 1944 showed that the Catalina cherry moth, *Melissopus latiferreanus* (Wlsm.), was a very important pest of walnuts in the Sacramento Valley. Nuts of most varieties were attacked although some, such as the Payne variety, appeared to be much more susceptible than others. The studies were conducted in the Gridley area of the Sacramento Valley, and it was found that the basic lead arsenate spray program that was effective in controlling the codling moth on the Payne variety of walnut at Linden, San Joaquin County, was not effective against the Catalina cherry moth. The codling-moth sprays were applied early in the season (first, May 4; second, June 1) and it was believed that this might have accounted for their failure to control the Catalina cherry moth, because the serious infestation of this pest did not occur until September. The finding of the 1944 investigations definitely showed that the Catalina cherry moth attacks nuts late in the season and if sprays are to be effective against it they should be applied late in the growing season. Further, infestation occurs, in part at least, after the walnut husks have started to crack, which would cause breaks in a protective spray covering.

The Second Season's Experiments.—The 1945 investigations were also conducted in the Gridley area and were designed to test the effectiveness of early sprays against the codling moth and late sprays against the Catalina cherry moth. The materials tested were standard lead arsenate, with safener, and DDT. These materials were used in the following spray treatments:

1. Check.
2. One spray of standard lead arsenate, plus ammoniacal copper carbonate, May 7.
3. Two sprays: standard lead arsenate, plus ammoniacal copper carbonate, May 7; and standard lead arsenate, August 17.
4. One spray of standard lead arsenate, August 17.
5. Two sprays: standard lead arsenate, plus ammoniacal copper carbonate, May 7; and DDT, August 17.
6. One spray of DDT, August 17.

The experiments were conducted on the Payne variety and consisted of plots of one tree each, replicated six times in a Latin square. The composition of the spray for the May 7 treatment, per 100 gallons, was as follows:

Standard lead arsenate	3 pounds
Safener (a commercial basic zinc-sulfate which contains 50 per cent zinc expressed as metallic)	1 pound
Liquid adhesive	½ pint
Light medium oil emulsion (98 per cent oil)	1 quart
Ammoniacal copper carbonate containing 3 per cent copper, expressed as metallic (to control walnut blight)	2 gallons

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Order of mixing: Lead arsenate and safener slurried and added to the tank when the water was up to the agitator rod, followed by liquid adhesive, and then oil when tank was ⅔ full. Ammoniacal copper carbonate was added when the tank was nearly full.

The composition of the standard lead arsenate spray, per 100 gallons, as used on August 17, was as follows:

Standard lead arsenate	3 pounds
Safener (a commercial basic zinc sulfate which contains 50 per cent zinc expressed as metallic)	1 pound
Paste type oil emulsion	⅓ gallon

Order of mixing: Lead arsenate and safener slurried and added to the tank when water was up to agitator rod. Oil was added when the tank was ¾ full.

The composition of the DDT spray per 100 gallons was as follows:

20 per cent wettable DDT powder	5 pounds
Paste type oil emulsion	⅓ gallon

Order of mixing: DDT powder was slowly added when water reached agitator rod, and the oil was added when the tank was ¾ full.

TABLE 28

COMPARISON OF SEVERAL SPRAY TREATMENTS IN CONTROLLING CATERPILLAR INFESTATION IN THE HARVESTED WALNUT CROP*

Treatment and date of application	Total number of nuts examined	Number of sound nuts	Number of culls other than infested	Number of infested nuts	Per cent of nuts infested
Check	1,299	1,168	87	44	3.38
One spray: standard lead arsenate, May 7	1,411	1,300	92	19	1.34
One spray: standard lead arsenate, August 17	1,300	1,208	75	17	1.30
Two sprays: standard lead arsenate, May 7 and August 17	1,366	1,278	78	10	0.73
One spray: standard lead arsenate, May 7; and one spray: DDT, August 17	1,338	1,246	77	15	1.12
One spray: DDT, August 17	1,344	1,232	92	20	1.49

* Determined from 10-pound samples taken from each tree, or a total of 60 pounds for each treatment.

Tree surveys were made about every 2 weeks during the growth of the crop. These showed that the standard lead arsenate spray applied on May 7 gave very good control of a very light infestation of the codling moth. The walnut crop in the plot area was harvested on September 25 and 26. The information obtained is summarized in table 28. Relatively few of the nuts in the harvested crop were found to be infested with codling moth. This is borne out by the fact that out of 39 larvae, found in examining the nuts, 32 were those of the Catalina cherry moth. The infestation of this insect was rather small, compared with that encountered in 1944 in the same orchard. In 1944, the total number of infested nuts in the harvested crop from the check plots amounted to nearly 25 per cent, while during the current year, the total number was only 3.38 per cent. The treatment that gave fewest infested nuts in the harvested crop was the one where the trees were sprayed twice with standard lead arsenate—once on May 7 and a second time on August 17. This treatment resulted in only 0.73 per cent of the nuts being infested. If the standard lead arsenate treat-

ments are compared with the comparable DDT treatments it will be noted that the former gave slightly better control. Whether this will prove to be true in the future remains to be determined. However, present information would indicate that at the concentrations used, standard lead arsenate is at least as effective, if not more so, against the Catalina cherry moth than is DDT.

Conclusions.—The results of two years of investigation have shown that the Catalina cherry moth seriously attacks walnuts. Although it is present during the entire growing season, the walnut crop is not seriously attacked until late in the season. The infestation frequently does not reach serious proportions until such varieties as the Payne are nearly ready to be harvested. Therefore, harvesting a crop at the earliest possible date will greatly help to reduce the infestation. Delayed harvest favors a severe infestation.

The lateness of the infestation indicates that sprays, to be effective, should be applied after the middle of August. Work conducted to the present time indicates that standard lead arsenate is more effective against the pest than is DDT.

Because of the lateness of the infestation, many small caterpillars are encountered in the harvested crop. This condition makes it impossible to determine accurately whether or not a nut is infested unless it is cracked. Therefore, a cracking test is necessary in order to ascertain the true degree of infestation. This practice will be carried out in future investigations.

EFFECT OF CODLING MOTH SPRAYS ON THE WALNUT APHID

A. E. MICHELBACHER,[67] GORDON L. SMITH,[68] AND CLARK SWANSON[69]

The effects of various spray programs on the walnut aphid, *Chromaphis juglandicola* (Kalt.), were observed during the use of the sprays against codling moth attacking walnuts. This was done to determine what effect, if any, the treatments would have on the aphid, which ranks with the codling moth as one of the more important insects attacking walnuts in central and northern California.

The principal insecticides used were basic lead arsenate, standard lead arsenate, and DDT. Other materials tested were trichloro-chloro-phenyl-phenyl-ethane, known as Tanatox, and a new organic stomach poison, known as HE 761. The composition of the sprays, and most of the other data pertaining to treatments, are given in the section "Control of Codling Moth on Payne Variety of Walnut."

Investigations were conducted at Linden and Farmington in San Joaquin County and in the Gridley area of Butte County. In making the surveys, the next to the terminal leaflet was examined for aphids. Six leaflets were collected at random about the skirt of each tree, and usually leaves were examined from all trees receiving the same treatment. A wide variation in the number of aphids found on the leaflets of the same tree was noted. In the Linden area

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the highest population was usually encountered on the northeast side of the tree.

Ten aphid surveys were made in the experimental plots at both Linden and Gridley. The results of these surveys indicated that trees sprayed with both basic lead arsenate and standard lead arsenate favored a build-up of aphid population more than did unsprayed trees. The results obtained for

TABLE 29

EFFECT OF VARIOUS CODLING MOTH SPRAY PROGRAMS ON THE WALNUT APHID AT LINDEN
(Entire experimental area dusted twice with a nicotine dust, June 15 and August 8)

Treatment and date applied	Average number of aphids per leaflet on the survey dates given*								
	May 21	May 31	June 12	June 26	July 10	July 24	Aug. 7	Aug. 23	Sept. 5
Check	3.71	3.51	9.50	0.0	0.40	5.61	30.50	0.35	0.80
Basic lead arsenate, May 3 and May 31	3.42	3.15	17.20	0.0	1.00	10.54	25.85	0.57	0.61
Standard lead arsenate, May 3	4.52	2.92	11.40	0.0	0.90	8.33	42.09	1.00	1.07
Standard lead arsenate, May 3 and May 31	3.83	2.22	12.10	0.0	1.71	10.73	39.95	0.73	0.80
DDT (1 pound per 100 gallons water), May 4	0.92	1.74	8.10	0.0	0.16	2.04	16.33	0.85	3.16
DDT (1 pound per 100 gallons water), May 4 and May 31	1.11	2.04	5.20	0.0	1.71	1.21	13.69	0.52	1.22
DDT (½ pound per 100 gallons water), May 4, and standard lead arsenate, May 31	0.57	1.70	7.40	0.0	3.52	9.64	40.23	0.71	3.21
Trichloro-chloro-phenyl-phenyl-ethane (1 pound per 100 gallons water), May 31	....	1.86	16.50	....	0.00	0.23	1.76	....	1.00
New organic stomach poison HE 761, May 4	2.79	5.40	19.50	0.0	0.45	0.41	8.00	....	2.33
New organic stomach poison HE 761, May 4 and May 31	2.79	5.70	59.50	0.28	0.41	5.70	37.95	....	2.45
DDT commercial application (1 pound per 100 gals. water), May 4	....	2.11	7.20	....	0.03	0.25	1.60	....	1.88
DDT commercial application (1 pound per 100 gals. water), May 4 and June 1	....	1.91	3.60	....	0.03	0.04	5.96	....	1.77
Commercial standard lead arsenate application, May 4	....	3.55	14.40	....	1.26	14.61	42.16	....	1,25
Commercial standard lead arsenate application, May 4 and June 1	....	1.41	7.30	....	0.80	14.63	62.43	....	2.66

* On May 3, the population of aphids averaged 0.21 per leaflet.

the Linden experimental plots are given in table 29 and those for the Gridley experiment, in table 30. In all instances where DDT was applied the aphid population was suppressed, and at Linden this material resulted in very good control. Trees treated with DDT showed the least evidence of aphid activity, and at harvest there was practically no sooty mold fungus on the leaves and nuts of the trees sprayed either once or twice with this material. Although marked control was obtained where DDT was applied to individual trees in the plot area, the best control resulted where the insecticide was applied to the experimental commercial blocks. Here the one- and two-spray treatments markedly reduced the aphid population, compared with the one- and two-spray

adjacent standard lead arsenate treatments. This difference is clearly shown in table 29. As in 1944, DDT killed many predators and exhibited a more profound residual action against them than it did against the aphid. The entire experimental area was dusted with nicotine dust on June 15, and again on August 8. Both of these dustings were made necessary because of large aphid populations that had developed with some of the other treatments. Even where DDT was used, it is probable that dusting with nicotine may have had to be resorted to, but, if so, it is possible that one dusting would have satisfactorily controlled the pest.

TABLE 30

EFFECT OF VARIOUS CODLING MOTH AND CATALINA CHERRY MOTH SPRAY PROGRAMS ON THE WALNUT APHID AT GRIDLEY

Treatment	Average number of aphids per leaflet on the survey dates given									
	May 7	May 18	June 1	June 15	June 29	July 13	July 26	Aug. 9	Aug. 20	Sept. 6
Check	9.8	4.50	2.52	3.13	0.01	0.0	0.19	0.28	2.75	3.41
One spray standard lead arsenate, May 7	9.8	6.38	2.42	3.73	0.00	0.0	0.46	0.65	2.60	4.08
One spray standard lead arsenate, August 17	9.8	4.50	2.52	3.13	0.01	0.0	0.19	0.28	0.79	4.69
Two sprays standard lead arsenate, May 7 and August 17	9.8	6.38	2.42	3.73	0.00	0.0	0.46	0.65	1.79	5.44
One spray standard lead arsenate, May 7, and DDT (1 pound per 100 gals.), August 17	9.8	6.38	2.42	3.73	0.00	0.0	0.46	0.65	0.04	1.86
One spray DDT (1 pound per 100 gals.), August 17	9.8	4.50	2.52	3.13	0.01	0.0	0.19	0.28	0.29	1.83

Trichloro-chloro-phenyl-phenyl-ethane (Tanatox) effected a rather marked control of the walnut aphid, a result which is well illustrated by the information contained in table 29.

The organic stomach poison HE 761 is apparently extremely toxic to certain predators of the walnut aphid. It has a long residual action against the green lacewing and the ladybird beetle, *Hippodamia*. Many of these insects were found dead on the ground following the second application of spray, on May 31. The number of predators killed must have run into the thousands and there was evidence that this material was still killing these beneficial insects as late as July 10. On the June 12 survey more ladybird beetles were found on trees sprayed twice with HE 761 than in any of the other treatments. Yet the ground was covered with recently killed individuals. The only explanation to be offered is that the extremely large aphid population (59.5 per leaflet) attracted the ladybird beetles to the trees, to be killed later by the insecticidal residue. If these trees had not been dusted with nicotine, it is very likely that they would have suffered very severe aphid injury, if not near defoliation.

Because of the very small aphid population encountered in the experimental area at Gridley (table 30) definite conclusions could not be drawn. A large

predator population probably accounted for the relatively small number of aphids. Yet, there is some evidence that trees sprayed with standard lead arsenate favor an aphid build-up more than do unsprayed trees. Also there is definite evidence that DDT suppressed the population.

Conclusions.—Based upon one season's work, there is some evidence that trees sprayed with standard lead arsenate or basic lead arsenate are more favorable for a build-up of walnut aphid population than are unsprayed trees.

DDT resulted in good control of the walnut aphid. As in 1944, the residue appeared to be more effective against the aphid predators than against the aphid itself. However, there was no marked build-up of the aphid population in any of the experimental plots at Linden or Gridley as there had been in 1944. A possible explanation of this result was not forthcoming until some DDT sprays were applied in late August to control the Catalina cherry moth, *Melissopus latiferreanus,* on walnuts in an orchard near Gridley. The sprays were applied by the grower, who neglected to do a thorough job. As a result, small islands throughout the trees were missed. Shortly after the sprays were applied, there was a marked build-up in the aphid population. The trees were dripping with honeydew, and the population was much higher than that which occurred on surrounding trees sprayed with standard lead arsenate. Apparently the predators that had escaped spraying moved from the unsprayed islands and were killed, while the aphids continued to reproduce in the unsprayed areas and moved out to infest the rest of the tree as soon as the residue was no longer effective against them. The relatively poor spraying job done in the orchard probably produced conditions somewhat comparable with those under which the 1944 DDT investigations were conducted. In 1944, a single row of trees was treated in an orchard that was very heavily infested with aphids. In fact, swarms of winged aphids could be seen flying. As a result, large numbers of aphids were ready to infest the DDT-sprayed trees as soon as the residue was no longer effective against them. Because the residue is effective longer against the predators than it is against the aphids, a large number of aphids was able to move into the sprayed trees and to build up a destructive population before the predators could establish themselves. It would appear that, in order to avoid a serious aphid infestation, DDT sprays should be thoroughly applied. Also, some evidence indicates that aphid control is most effective when a large area is treated, but only if there is thoroughness of application.

Based on the 1945 season's work, trichloro-chloro-phenyl-phenyl-ethane (Tanatox) appeared to be very effective in controlling the walnut aphid.

The organic stomach poison HE 761 is very destructive to predators of the walnut aphid. Its long residual action against the predators gives the aphid an opportunity to build up a large and destructive population.

DDT AND RELATED COMPOUNDS FOR CONTROL OF BLACK SCALE ON OLIVES

E. M. STAFFORD[70] AND H. S. HINKLEY[71]

In several of the areas in California where black scale on olives is a problem, the hatching of scale eggs has extended through the summer and fall. In addition to the constant search for more toxic insecticides, there is a need for a long-lasting one that can be used in these areas where the hatching of black scale eggs is prolonged. Also, many growers object to the yearly use of petroleum oil sprays which is one of the recommended controls. In a preliminary trial in 1944, DDT showed a great deal of promise and appeared to possess the desired characters needed for the control of this pest. The investigation was therefore expanded in 1945.

Experimental sprays were applied on small Sevillano olive trees near Corning, California, on July 31 or August 1, 1945. At this time nearly all of the scale eggs had hatched. The composition of the sprays per 100 gallons of water was as follows:

1. Four pounds 20 per cent DDT wettable powder.
2. Five pounds 20 per cent DDT wettable powder.
3. Five pounds 20 per cent DDT wettable powder and ½ gallon light soluble oil.
4. Three pounds 20 per cent DDT wettable powder and 3 pounds wettable sulfur.
5. Five pounds 20 per cent trichloro-chloro-phenyl-phenyl-ethane (Tanatox) and 8 ounces blood albumin spreader.
6. Four pounds dichlorodiphenyl-dichloroethane (DDD) 25 per cent wettable powder.
7. One half pound 666 (benzene hexachloride 40 per cent gamma isomer) and 8 ounces blood albumin spreader.
8. One gallon light soluble oil, ⅞ ounce derris resins (30 per cent rotenone), 1¼ liquid ounces Velsicol AR-60, and 1⅛ liquid ounces acetone.

Twigs heavily infested with overwintered scale were collected and examined on August 31 and again on October 16, 1945. On October 16, twigs were also collected from adjoining trees which had received a commercial application of light oil on August 30. The results of the leaf counts are shown in table 31.

It appeared that by employing DDT the use of spray oil could be avoided or the concentration of spray oil could be greatly reduced. The addition of ½ per cent light oil to the DDT wettable powder improved control of young black scale. The compounds related to DDT, namely DDD and Tanatox, were not as so effective in controlling black scale. Benzene hexachloride also gave poor control. Light oil containing rotenone gave good control. In contrast to the 1944 season, the period of hatching of the scale eggs did not extend through August in this orchard so that the persistent effect of the DDT could not be well tested or compared, in this respect, with the oil-rotenone treatment.

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[71] Assistant in Agricultural Extension.

Analyses of DDT residues on leaves and on olives before and after processing may be found in the report on spray residues (table 36, p. 105). It is of interest to note: the persistance of large amounts of DDT on the olive leaves; the presence of a large amount of DDT in olive oil extracted from olives from which the DDT had been removed from the surface with benzene; and the presence of DDT on olives which had been processed in the regular commercial manner.

TABLE 31

NUMBER OF SCALY LEAVES WITH NO LIVE SCALES, BASED UPON EXAMINATION OF 100 SCALY OLIVE LEAVES, AT CORNING

Treatment per 100 gallons of spray	Number of leaves with no live scales	
	August 31	October 16
Untreated	9	..
4 pounds 20 per cent DDT wettable powder	88	91
5 pounds 20 per cent DDT wettable powder	81	93
5 pounds 20 per cent DDT wettable powder; ½ gallon light soluble oil	97	97
3 pounds 20 per cent DDT wettable powder; 3 pounds wettable sulfur	66	80
5 pounds 20 per cent Tanatox; 8 ounces blood albumin spreader	20	43
4 pounds 25 per cent DDD wettable powder	62	73
½ pound 666 (40 per cent gamma isomer); 8 ounces blood albumin spreader	12	31
1 gallon light soluble oil; ⅞ ounce derris resins (30 per cent rotenone); 1¼ liquid ounces Velsicol AR-60; 1⅛ liquid ounces acetone	92	93

TABLE 32

NUMBER OF SCALY LEAVES WITH NO LIVE SCALES, BASED UPON EXAMINATION OF 100 SCALY OLIVE LEAVES, AT ORLAND

Treatment per 100 gallons of spray	Number of leaves with no live scales on August 31
4 pounds 20 per cent DDT wettable powder; 1 quart light medium soluble oil	49
2 gallons light-medium soluble oil	11

On August 1, a block of Sevillano olive trees at Orland, California, was sprayed with 4 pounds 20 per cent DDT wettable powder and 1 quart light-medium soluble oil per 100 gallons of water for a comparison with 2 gallons light-medium soluble oil per 100 gallons of water applied the same day. In this orchard the hatching of black scale eggs extended through August. The trees were heavily infested. At the time of spray application, which was made by the grower, there were a few larger black scales that apparently had migrated from the leaves and settled on the twigs.

On August 31, twigs heavily infested with overwintered scales were collected and examined. The results are given in table 32.

On October 16, live scale could be readily found on the twigs of the trees

which had been sprayed with either of the two treatments. It thus appears that when the hatching period of the scale eggs is extended through several summer months, DDT sprays for the control of very young black scale on olives might better be applied at an earlier date than an oil spray.

Conclusions.—In 1944 and 1945, DDT both as a wettable powder and dissolved in spray oil showed promise as a control for black scale on olives. A great deal more must be learned regarding DDT residues and the penetrations of DDT into olives before recommendations can be made. The preliminary analyses show that there is sufficient penetration of DDT into olives to make the practice of spraying olive fruit with any form of DDT an extremely hazardous one.

TESTS OF SABADILLA FOR CONTROLLING THE GREEN STINKBUG ON PEACHES

NORMAN W. FRAZIER[72]

Small-scale field tests are made of the effect of sabadilla on the green stinkbug, *Acrosternum hilaris* (Say), which was infesting a peach orchard near Exeter. A commercial 10 per cent sabadilla dust was applied first to several trees by means of a hand duster; later the entire 5-acre orchard was dusted with a power duster. Both treatments appeared to give excellent kill and it is probable that further testing would prove sabadilla an effective insecticide for use in the control of the green stinkbug.

The results of the present tests have been previously reported in detail.[73]

[72] Junior Entomologist in the Experiment Station.

[73] Frazier, Norman W. Sabadilla for control of the green stinkbug. Jour. Econ. Ent. (In press.)

CONTROL OF FLIES IN DAIRY BARNS[74]

A. E. MICHELBACHER[75] AND GORDON L. SMITH[76]

Because of the exceptionally good results obtained with DDT for the control of flies in dairy barns in 1944, work was continued and expanded in 1945. Numerous dairies located for the most part in San Joaquin and Stanislaus counties were selected for the investigations. The work was conducted more on a demonstrational than on an experimental basis. A number of different spray mixtures were tested. These included kerosene-DDT, DDT dissolved in Velsicol (AR-50), and DDT water suspension sprays.

DDT in kerosene was used at two different concentrations. In one test DDT was used at the rate of 2⅔ ounces per gallon and in the other, at the rate of 5⅓ ounces per gallon. A bucket sprayer was used and the spray was applied under 50 pounds' pressure. The dairies used in these tests were located near Escalon and the sprays were applied on February 12. The 5⅓-ounce mixture was applied to a 24-cow barn, of cement construction with a corrugated iron roof. Approximately 14 gallons of spray were needed to cover the interior surface of the barn, including the alleyway, milkroom, and washroom. The spray was applied at a rate that would leave a deposit of about 400 milligrams of DDT per square foot. The 2⅔-ounce mixture was applied to a 16-cow barn of hollow tile construction with cement facing and corrugated iron roof. Approximately 9½ gallons of spray were needed to spray the interior surface of the barn.

In applying the sprays, every effort was made to avoid getting any of the spray on any utensils or feedstuff. The feed troughs were hosed clean before the spray was applied and again right after spraying in order to remove as much spray residue as possible. In applying the sprays, particularly overhead (upper walls and roof) the spray tended to drift onto the operator. As a result, the kerosene caused some facial burning which, although not serious, could have resulted in grave trouble under longer exposure without protection. Certainly, if a DDT-kerosene spray is used on an extensive scale the operator should use a respirator and be otherwise protected from the drift. The control obtained with both concentrations was good and the treatments remained effective until the first week in June. In the milkroom and washroom the treatments remained effective longer than elsewhere in the barns, and good control resulted until about the first of July.

Although good results were obtained with the DDT-kerosene solution, the control was no better than that obtained with DDT water suspension sprays. Based on the actual amount of DDT used, water suspension sprays proved to be more effective. The probable reason for this is the fact that the kerosene carries part of the DDT into the surface sprayed, where it is lost, while a water suspension spray deposits the DDT on the surface. Further, some fire

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[74] This investigation was conducted in coöperation with George A. Cross, Assistant Farm Advisor of Stanislaus County, and Dan L. Dieter, Assistant Farm Advisor of San Joaquin County. The work could not have been successfully undertaken without their help. Dr. M. A. Stewart also gave many helpful suggestions.

[75] Assistant Professor of Entomology and Assistant Entomologist in the Experiment Station.

[76] Associate in the Experiment Station.

hazard is involved where a kerosene spray is used. Also, a DDT water suspension spray is a much safer material to use since it is not harmful to man or animal if some of the spray is accidentally deposited on the skin. For these reasons, work with DDT-kerosene solution was discontinued and time was mostly devoted to a study of DDT water suspension sprays.

Water suspension sprays were used at the rate of 2 to 4 pounds of actual DDT to 100 gallons of spray. Incorporated in the powders for spray, which contained either 20 or 50 per cent of DDT were wetting agents. A typical spray mixture used was as follows:

20 per cent DDT powder	10 or 20 pounds
Light oil emulsion	½ gallon
Water	100 gallons

All spraying was done with a Bean sprayer and the materials were applied at pressures that ranged from 100 to 400 pounds. In mixing the spray, the DDT was slurried in a large deep container and then slowly added to the spray tank when it was one half full. The oil was slowly added when the tank was two thirds full.

Before spraying a barn the following precautions were taken:

1. All milk cans and utensils were put under cover or removed.
2. The milk cooler and sinks were covered with heavy paper or other protective material.
3. All feedstuff was removed or carefully covered so that it would not become wet by the spray.
4. Feed troughs were hosed clean just before and after the spray was applied in order to reduce to a minimum the residue that might collect in them.

The interior surface of the barns, including the alleyway, washroom, and milk-cooling room, was sprayed. The ceiling and walls of the feed storage room were sprayed if it was possible to protect the feedstuffs from the spray. Frequently the calf barn and bull pen were also treated. The amount of material needed to spray a barn depended upon its size. To do a thorough job, 40 to 60 gallons of dilute spray were needed to cover a 24-cow barn.

On February 27, three dairy barns were treated in Stanislaus County. One of these included the barn that had been under test in 1944. In all cases good control resulted and the spray remained effective until at least the first of June, although flies were still being killed at a much later date. Two of the barns were sprayed with DDT at the rate of 2 pounds to 100 gallons and the third barn at the rate of 4 pounds of DDT to 100 gallons of water. The 4-pound dosage appeared to be the most effective as it was still killing flies on July 21 when all three barns were sprayed again. These dairies were sprayed for a third time between September 25 and October 1. During the summer other barns were put under test and in practically all cases exceptionally good control of flies resulted. All the information obtained clearly indicated that a DDT residual spray remains effective much longer during the cooler season than it does during the hottest part of the year. As used in these experiments, the residue remained effective for as long as three or more months in the winter, but in the summer the effective period of control will only last for about six

weeks. It does appear that three, and not more than four, spray applications are all that are necessary to effectively control flies throughout the year.

That the control of flies in dairy barns might well result in increased milk production is indicated in the dairy which has been under test for one year. The butterfat production per cow increased from 394 to 429 pounds. Although other factors may have played a part in bringing about this increase, it is believed that fly control was an important factor.

One dairy barn was sprayed with a DDT-Velsicol-water spray. Two pounds of DDT were dissolved in 2 quarts of Velsicol (AR-50) and added to 50 gallons of water along with 2 ounces of blood albumin. This mixture did not give such good control as that obtained with a DDT-water suspension spray. However, no definite conclusions can be reached because of the very limited nature of the experiment.

In mid-October some dairy barns in Fresno County were put under test with dichlorodiphenyl-dichloroethane (DDD). This material is somewhat similar to DDT and shows considerable promise as a residual spray for fly control. Where used, it gave very good control.

Conclusions: DDT gave very good control of flies in dairy barns. The studies indicate that not more than three properly timed spray applications should be necessary to give satisfactory control of flies for a year period. However, if best results are to be obtained, flies should be controlled in all livestock structures on any particular ranch. Although good control was obtained with DDT-kerosene sprays, it is felt that they should not be used for any extensive spraying for the following reasons: (1) Their use involves some slight fire hazard; (2) They are no more effective than water suspension sprays; (3) There is some evidence that the kerosene carries the DDT into porous surfaces where it is lost; (4) DDT in kerosene is readily absorbed through the skin, whereas a water suspension spray is harmless if accidentally sprayed or spilled on the skin of man or animals; (5) Kerosene is a poisonous substance and causes irritation if the body is exposed to it for any considerable period of time.

Although water suspension sprays that contained 2 pounds of actual DDT to 100 gallons of water gave very good control, it is believed that a 4-pound dosage gives enough additional control to justify the extra cost. Water suspension sprays are best applied with a power sprayer, and it appears that it might be practical for a cow-testing association or similar organization to purchase a sprayer and do the spraying for its members. If a farmer does not have proper equipment, it is possible for him to hire a professional operator to do the work.

The initial spraying in the spring should be delayed until flies first become annoying. The second spray can then probably be delayed until sometime in July and the third applied near the end of August or in September. Where fly control is rather extensive, it may be possible to reduce the number of spray applications to less than three but this still remains to be determined.

In the absence of power equipment it may be desirable for a farmer to use a DDT emulsion. Such products are available and if properly applied, they give good control. The stock emulsions may contain as much as 25 per cent DDT. Such stock emulsions should be handled with considerable caution and

if some of the concentrate is spilled on the skin, it should be washed off immediately with soap and water. Our investigations with DDT applied as water emulsions have been very limited but there is evidence that effective control can be obtained where the dilute spray contains ½ per cent of DDT.

Chickens are sometimes allowed to run in livestock structures. They eat the flies that have been killed by the DDT. To the present time no harmful effects have been observed, but it is a problem that bears watching.

Investigations conducted by H. S. Telford and J. E. Guthrie[77] have shown that the toxic principle of DDT is transmitted through the milk of white rats and goats, when fed food contaminated with DDT. These findings point out the importance of avoiding the spraying of feedstuffs and utensils when applying DDT to barns and structures housing livestock. DDT is a poison and it should be used with a great deal of caution.

[77] Telford, H. S., and J. E. Guthrie. Transmission of the toxicity of DDT through the milk of white rats and goats. Science, (n.s.) **102**(2660):646. December, 1945.

SOME COMPARATIVE LABORATORY TESTS WITH MINUTE DOSAGES OF DDT, 666, AND DDD ON MOSQUITO LARVAE AND PUPAE

WILLIAM B. HERMS[78]

While conducting exploratory laboratory tests with DDT on the immature stages of mosquitoes during December, 1943, the author was impressed with the high toxicity of minute dosages of this chemical. The procedure consisted of placing 10 full-grown (fourth instar) larvae and 10 pupae of *Culex tarsalis* in small tumblers containing 50 cc of tap water and then adding DDT (purified, 98+ per cent) dissolved in absolute alcohol so as to produce, when added to the water, dilutions of DDT ranging from one million to six hundred millions, that is, 1 part DDT to one, two, five, ten, thirty, fifty, one hundred, two hundred, and six hundred million parts of water. Dilutions of 1 part per million killed all larvae in about 1 hour; dilutions of two millions killed in less than 1½ hours. Pupae were killed within 12 hours. Weaker dilutions required progressively longer time to kill the larvae and did not kill all of the pupae; however, as the adult mosquitoes emerged from surviving pupae many of them died on the surface of the water. Thus, a dilution of 1 part DDT to thirty million parts of water killed all the larvae in about 50 hours, but only 2 of the 10 pupae were dead in 72 hours. However, 8 adults emerged; of these, 6 died on the surface, and 2 were apparently normal. At dilutions of fifty millions, 8 out of the 10 larvae were killed in 72 hours; 2 succeeded in pupating; and at the end of 96 hours these, together with the 10 pupae, had emerged. The adults emerged normally, thus indicating no ill effect on the adults or pupae at this concentration.

Though concentrations as low as 1 part DDT to six hundred million parts of water were used, the results were inconclusive. In all cases third- and fourth-instar larvae and pupae similarly confined in receptacles of tap water, but not dosed with DDT, lived on normally. Room conditions varied little from 70°F and 50 per cent relative humidity.

It was furthermore observed, while conducting these early exploratory tests, that sufficient DDT residue remained in emptied containers having had a dilution of 1 part per million to kill all fresh larvae added to refilled (fresh tap water) containers in about 1½ hours. A second change of fresh tap water resulted likewise in the death of larvae in less than 18 hours. Adult mosquitoes placed in a dry jar which had previously contained a dilution of 1 part DDT to six million parts water were killed on contact with the walls of the glass in 24 hours, the jar having been dry by evaporation for 57 days.

Further tests of a preliminary nature were made at intervals during 1944 and early in 1945, using various species of culicines, particularly *Culiseta inornata* and *C. incidens*. No difference in species reaction to either DDT or 666 was observed, hence the several species listed were used indiscriminately in the earlier tests. Third-instar larvae are killed more quickly than fourth, as are also the larvae of smaller species.

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In June, 1945, the author secured some samples of hexachloro-cyclohexane, a chemical known as 666 ($C_6H_6Cl_6$), which was similarly tested with rather interesting results particularly because of the fact that the two isomers tested had decidedly different toxic effects. Thus a trace of gamma 666 (unpurified) dissolved in 95 per cent alcohol (dilution undetermined) stirred into 50 cc of tap water with 10 larvae killed all in about 1 hour. A similar dilution in xylol killed all larvae in about 22 hours. As a check, it was found that a trace of alcohol or xylol alone did not injure the larvae. Dosages with similar dilutions

TABLE 33

A TYPICAL SERIES SHOWING SOME COMPARATIVE TESTS WITH MINUTE DOSAGES OF DDT, GAMMA 666, AND DDD ON FOURTH-INSTAR LARVAE AND PUPAE OF *Culiseta incidens*

(Room temperature 70° F; RH, 50 per cent)

Approximate dilution in tap water	Time required for action of the chemicals								
	DDT (98+ per cent)			666 (90± per cent)			DDD (99 per cent)		
	90 per cent of larvae down	100 per cent of larvae dead	100 per cent of pupae dead	90 per cent of larvae down	100 per cent of larvae dead	100 per cent of pupae dead	90 per cent of larvae down	100 per cent of larvae dead	100 per cent of pupae dead
	minutes	*minutes*	*hours*	*minutes*	*minutes*	*hours*	*minutes*	*minutes*	*hours*
1,000,000......	25	60	6	20	35	4¼	30	65	7½
2,000,000......	35	75	9½	50	85	8¼	35	150	..
3,000,000......	65	115	9½	80	135	7½	55	150	..
4,000,000......	80	135	30	100	140	15	60	180	..
5,000,000......	100	195	30	105	195	48	85	120	32
10,000,000......	450	....	29	1470	..	55	..	..	..
20,000,000......	650	....	65	....	....	70	....	..	..

of the delta isomer in either xylol or alcohol proved ineffective up to 72 hours of exposure. No further work was done with this latter isomer. Later tests were made with more highly purified (80 per cent) gamma 666 with about the same results, but discontinued later in favor of the more highly purified material as set forth below.

The above described crude preliminary tests led to a series of comparative and simultaneous tests. In these tests, purified DDT (98+ per cent) and purified 666 gamma (90± per cent) were used, and in addition a few tests with purified DDD (dichlorodiphenyl-dichloroethane), also known as DTE.[79] Stock solutions of the various chemicals were made up in absolute alcohol to constitute a dilution of 0.01 milligram per cubic centimeter. As with the early exploratory tests, small glass tumblers were used containing 50 cc of tap water. Fourth-instar larvae and pupae (10 of each in separate containers) of *Culiseta incidens* were tested. Checks were run in tap water and dilutions of alcohol alone (see "Discussion of Results"). Dilutions of the chemicals were made by adding stock solution in sufficient quantity (using micropipette) to the tap water containing the mosquito larvae or pupae to make the desired dilution. Obviously the dilutions were only approximate because of difficulties in determining the degree of purity of the chemical, and

[79] Dionier, C. C., and H. A. Jones. DTE, 1,1-dichloro-2, 2-bis, (*p*-chlorophenyl) ethane as an anopheline larvacide. Science, (n.s.) 104:13–14, 1946.

the uncertain accuracy of measurement of both tap water and solution. Larvae, after falling and rising several times, eventually dropped to the bottom when overcome by the solution, but continued to squirm and jerk for several minutes. They were recorded as down only when they did not rise on tapping the glass. They were recorded dead after all movement had apparently ceased. Air bubbles at the opening of the siphon frequently caused larvae to rise. Pupae usually died at the surface, very few sinking to the bottom until later. Pupae were recorded as dead when no more movement was observed. The results of a typical series of experiments are shown in table 33.

Discussion of Results.—Because of the wide variation in results obtained in tests with dilutions weaker than 1 part per 20,000,000 these are not included in table 33. Considerable additional work will be necessary with weaker dilutions although many tests were made by the author with dilutions of 1 part per 30,000,000; 1 to 50,000,000; 1 to 100,000,000; and 1 to 150,000,000. The results were too scattered and too uncertain to permit of proper analysis. The series reported in table 33 was replicated many times with fairly even results. It would appear that a dilution of DDT down to 1 part per 20,000,000 for fourth-instar larvae and pupae is fairly dependable. A dilution of gamma 666 of 1 part per 10,000,000 for larvae and 1 part per 20,000,000 for pupae seems also to be dependable. It is interesting to note that gamma 666 has considerable pupacidal value. DDD as far as the tests have been done gives about the same results as DDT. The true toxic efficiency of the chemicals tested is not reflected in table 33 for dilutions stronger than 1 part per 5,000,000, since the alcohol alone in such dilutions has lethal effect on both larvae and pupae, though at a slower rate. Further work is in progress; the data presented here are in the nature of a progress report.

EFFECTIVENESS OF DDT AND OTHER ORGANIC CHEMICALS IN PREVENTING TERMITES FROM ENTERING FOOD PACKAGES

W. M. HOSKINS[80] AND W. F. CHAMBERLAIN[81]

The usefulness of some 65 chemicals in preventing the damp-wood termites, *Zootermopsis angusticollis* and *Z. nevadensis* and the dry-wood termite, *Kalotermes minor,* from penetrating various materials used in making food containers has been tested by exposing treated materials, in the form of a circular arena 8.5 cm in diameter, to these insects. The chemicals were applied in solution in melted wax or in other solvents. All tests were carried out in a cabinet having a relative humidity close to 80 per cent and temperature of approximately 29° C. Observations were made of termite mortality and of the scarification and holes made by them in the materials.

Results.—Untreated materials such as 50-pound kraft paper, light cardboard, and number 300 cellophane are penetrated in 1 to 7 days. The following chemicals, when used in wax, delayed penetration over 6 months: DDT at 5 per cent; 3, 5-dinitro-*o*-cresol at 2 per cent; phenothiazine salt of 3, 5-dinitro-*o*-cresol at 1 per cent; 3, 5-dinitro-*o*-cresyl trichloroacetate at 1 per cent; 3, 5-dinitro-*o*-cresyl acetate at 1 per cent; diphenylamine salt of 3, 5-dinitro-*o*-cresol at 2 per cent; and phenothiazine at 2 per cent. DDT at 2 per cent prevented entry for over 5 months but less than 6 months. All materials were somewhat less effective when applied in acetone solution. Slight repellency was shown by all dinitro phenol compounds, by Lethane A 90, by coumarin and thiocoumarin (the most repellent material tested), by terpineol and quinoline. Numerous essential oils were very slightly repellent but nontoxic. DDT did not appear to be repellent to a detectable degree at concentrations up to 5 per cent, which was the highest used.

The two species of damp-wood termites showed no difference in behavior nor in ability to penetrate treated and untreated materials. They gnawed large areas, resulting in large irregular holes, but the dry-wood termites made small holes directly through. No definite difference in ability to penetrate was shown by the three species.

This work has revealed a persistent toxicity from DDT, phenothiazine, and several compounds of the dinitro phenol group. The latter have the disadvantage of staining the packages. Future work with these materials in preventing termite attack on wood is planned.

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AN ANALYTICAL METHOD FOR THE DETERMINATION OF DDT DEPOSITS AND RESIDUES DURING 1945 ON GRAPES, PEARS, SPINACH, AND ANIMAL HAIR

W. M. HOSKINS[82]

The general analytical procedure used in these determinations was described in detail in the report on investigations with DDT in California, 1944.[83] It depends upon liberation of water-soluble chloride from DDT by treatment with alcoholic alkali and subsequent titration with standard silver nitrate solution.

TABLE 34

DDT Residue on Emperor Grapes

Pounds of 5 per cent dust applied per acre	To what applied	Date treatment applied	Date samples collected	DDT residue, p.p.m.
20	Vines	August 3	August 24	5.9
20	Vines	June 22	August 24	1.7
20	Vines	May 8 June 22	August 24	2.7
20	Vines	May 8 June 22 August 3	August 24	9.7
20	Vines	May 8	August 24	0.9
25	Grass covercrop	August 7	August 24	6.3
22	Vines	August 13	August 24	6.8
25	Grass covercrop	August 24	August 24	8.5
30*	Vines	June 10	July 26	2.0
Check	....	....	August 24	0.0

* Four per cent dust.

Difficulties were encountered with samples containing much fatty material or which had been treated with sulfur; these were overcome in the following manner. After the treatment with alkali and evaporating to dryness, the residue was made acidic and thoroughly extracted wth benzene, thereby removing the fatty acids. Slight excess of alkali was then added, the solution evaporated to a chosen volume and titrated in the usual manner. To remove the interference from sulfur, the alkaline residue was treated with enough sodium nitrate (usually not over 1 gram) to give a clear melt when heated moderately. This was then cooled and titrated as usual. When the sample contained sulfur as well as much fatty material, both modifications of the general procedure were used.

Grapes.—Samples, weighing approximately 2 pounds, from a dusted vineyard of Emperor grapes near Woodlake, California, were analyzed during October for DDT residue. Treatments and results are shown in table 34. The dust contained 5 per cent commercial DDT, 50 per cent dusting sulfur, and 45 per cent inert filler. It was applied directly to the vines in the ordinary manner, except as noted in the table. The samples were kept in cold storage

[82] Professor of Entomology and Entomologist in the Experiment Station.

[83] California Agricultural Experiment Station. Investigations with DDT in California, 1944. (A preliminary report prepared under the direction of the Division of Entomology and Parasitology.) (Lithoprinted.) 33 p. March, 1945.

between the time of receipt and analysis. There was close agreement in duplicate analyses; the data given are averages.

Analyses were also made of grapes from a vineyard treated with DDT-kerosene solutions applied as a vapo-spray, on May 29, at the rate of 5 gallons per acre. The analyses were made during September and October and the results are given in table 35.

TABLE 35

DDT RESIDUE ON VAPO-SPRAYED GRAPES*

Concentration of DDT, per cent	Variety of grapes	Date samples collected	DDT residue, p.p.m.
0.6	Thompson Seedless	July 25	1.0
1.2	Thompson Seedless	July 25	1.6
1.2	Red Malaga	July 25	3.2
0.6	Carignane	September 5	0.5
1.2	Carignane	September 5	1.9
2.4	Carignane	September 5	3.5
0.6	White Malaga	September 5	2.6
1.2	White Malaga	September 5	2.4
2.4	White Malaga	September 5	5.8

* Samples made available through kindness of Mr. Paul Jones of the Shell Oil Company.

Pears.—Only one sample of pears was analyzed. This had been treated with two lead arsenate sprays in the calyx period and three sprays of 5 pounds of 20 per cent DDT per 100 gallons on May 9, June 1, and July 2. The pears were picked about August 10 and analyzed September 10 and found to contain 7.5 p.p.m. of DDT.

Spinach.—Samples of spinach in Monterey County were obtained from a field treated on September 3 with a spray containing 10 pounds of 20 per cent wettable DDT per 100 gallons, applied at the rates of 100, 200, and 300 gallons per acre. The samples were collected on October 23 and analyzed during November. The DDT residue in p.p.m. was 2.6, 3.3, and 4.0 for the 100-, 200-, and 300-gallon applications respectively.

Hair from Animals.—Three bulls were thoroughly sprayed with a suspension of 10 pounds of 20 per cent wettable DDT powder per 100 gallons on September 8. Hair from the animals' backs and sides was clipped on September 15, made into a composite sample and analyzed on November 1 and found to contain 650 p.p.m. DDT. Another sample clipped on September 22 and analyzed on November 26 contained 107 p.p.m. These data give no information on the amount of DDT on the skin but show that considerable remained on the hair. A third sample clipped on December 5 and analyzed shortly thereafter showed no detectable DDT remaining.

DDT DEPOSITS AND RESIDUES ON OLIVES, GRAPES, CABBAGE, GREEN BEANS, AND PEAS[84]

H. G. REIBER[85] AND E. M. STAFFORD[86]

Samples of plant material for DDT analyses were collected in the field, brought to Davis and either immediately prepared for analysis or placed in cold storage for analysis later. The sample was placed in a jar and shaken with benzene for about one-half minute. The benzene was then poured into a bottle and the sample was again washed with benzene. Samples were usually washed with four portions of benzene, using a total of 500 milliliters. The combined benzene washings were used for DDT analyses. The analyses are summarized in table 36.

In the nitration method, developed by Schechter and Haller,[87] the DDT residue, after evaporating off the benzene, is nitrated with a few milliliters of equal volumes of concentrated H_2SO_4 and fuming HNO_3, the nitrated derivative extracted with ether, the ether evaporated, and the residue taken up with benzene. The color is developed with sodium metholate and read in the colorimeter.

In the Gunther method the DDT residue after evaporating off the benzene, is digested with 1.0 *N* alcoholic NaOH, following which it is neutralized and titrated with 0.01 *N* $AgNO_3$. The Hoskins modification of the Gunther method[88] provides for the removal of the decomposition product of DDT after alkylation, with ether, the ether discarded, the residual solution evaporated, and the residue fused with $NaNO_3$.

Results as obtained by the modified Gunther method as compared to those obtained by the nitration method appear in table 37.

[84] The DDT treatments were made and the samples for analysis taken by W. H. Lange, Jr., L. M. Smith, and E. M. Stafford of the Entomology and Parasitology Division, at Davis. All residue analyses were made by H. W. Allinger of the Division of Chemistry. The analyses for the olive oil were made by H. Goss of the Division of Animal Husbandry.

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[86] Assistant Entomologist in the Experiment Station.

[87] Schechter, M. S., and H. S. Haller. Colorimetric tests for DDT and related compounds. Amer. Chem. Soc. Jour. 66:2129–30. 1944.

[88] Gunther, F. A. Quantitative estimation of DDT and of DDT spray or dust deposits. Analyt. Ed., Ind. Eng. Chem. 17:149–50. 1945.

TABLE 36

ANALYSES OF DDT RESIDUES ON GRAPES, CABBAGE, GREEN BEANS, GREEN PEAS, OLIVES, AND OF DDT IN OLIVE OIL*

Composition of spray per 100 gallons, or of dust per 100 pounds, or per cent of DDT in vapo-spray	Date treated	Portion of plant analyzed	Date sample taken	DDT in parts per million	Remarks
Black Corinth grapes—sprayed					
4 pounds 20 per cent DDT wettable powder, 1 gallon kerosene	May 6	Berries	June 13	none	Vineyard dusted with sulfur
4 pounds 20 per cent DDT wettable powder, 1 gallon kerosene	July 17	Berries	July 17	7.5	Vineyard dusted with sulfur
4 pounds 20 per cent DDT wettable powder, 1 gallon kerosene	July 17	Berries	August 4	3.0	Vineyard dusted with sulfur
Emperor grapes—dusted					
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	May 8	Berries	September 13	1.0	Dust directed on vines
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	June 22	Berries	September 13	0.7	Dust directed on vines
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	May 8 June 22	Berries	September 13	1.1	Dust directed on vines
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	August 3	Berries	September 13	1.8	Dust directed on vines
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	May 8 June 22 August 3	Berries	September 13	1.7	Dust directed on vines
5 pounds DDT, 50 pounds sulfur, 45 pounds inert carrier	August 24	Berries	September 13	1.6	Dust directed on covercrop
Thompson Seedless grapes—vapo-sprayed					
Emulsion containing 20 per cent DDT at 15 gallons per acre	September 10	Berries	September 14	3.4	Vineyard dusted with sulfur
1.2 per cent DDT in vapo-spray base oil—6.7 gallons per acre	September 10	Berries	September 14	1.1	Vineyard dusted with sulfur

* Unless otherwise noted, 453-gram samples were used.

TABLE 36—(*Continued*)

ANALYSES OF DDT RESIDUES ON GRAPES, CABBAGE, GREEN BEANS, GREEN PEAS, OLIVES, AND OF DDT IN OLIVE OIL*

Composition of spray per 100 gallons, or of dust per 100 pounds, or per cent of DDT in vapo-spray	Date treated	Portion of plant analyzed	Date sample taken	DDT in parts per million	Remarks
Sevillano olives—sprayed					
5 pounds 20 per cent DDT wettable powder, 0.5 gallon light soluble oil	July 31	Olives	August 30	19.3	
5 pounds 20 per cent DDT wettable powder, 0.5 gallon light soluble oil	July 31	Olives	October 16	9.5	
5 pounds 20 per cent DDT wettable powder, 0.5 gallon light soluble oil	July 31	Leaves	October 16	169.0	5.1-gram sample
5 pounds 20 per cent DDT wettable powder, 0.5 gallon light soluble oil	July 31	Leaves	October 16	184.0	51-gram sample
5 pounds 20 per cent DDT wettable powder	July 31	Olives	October 16	2.5	553-gram sample
5 pounds 20 per cent DDT wettable powder	July 31	Olives	October 16	2.3	1,979-gram sample washed with 500 ml benzene for 5 minutes, 430 ml recovered
5 pounds 20 per cent DDT wettable powder	July 31	Olives	October 16	0.7	Above sample washed a second time with 500 ml benzene for 5 minutes, 488 ml recovered
4 pounds 20 per cent DDT wettable powder, 0.25 gallon light medium soluble oil	August 1	Olives	October 16	6.9	
5 pounds 20 per cent DDT wettable powder	July 31	Olives	October 16	none	1,090-gram sample processed by Lindsay Ripe Olive Company
5 pounds 20 per cent DDT wettable powder, 0.5 gallon light soluble oil	July 31	Olives	October 16	2.0	523-gram sample processed by Lindsay Ripe Olive Company
Mission olives—sprayed					
4 pounds 20 per cent DDT wettable powder, 0.25 gallon medium soluble oil	August 10	Olives	October 23	7.9	
4 pounds 20 per cent DDT wettable powder, 0.25 gallon medium soluble oil	August 10	Oil	October 23	116.0	947-gram sample ground and extracted with ether
4 pounds 20 per cent DDT wettable powder, 0.25 gallon medium soluble oil	August 10	Oil	October 23	45.0	453-gram sample stripped with benzene. Oil pressed from olives and separated by centrifuge

Cabbage—dusted					
3 pounds DDT, 97 pounds inert carrier	April 4, May 10	Outer leaves	June 15	4.2	464-gram sample
3 pounds DDT, 97 pounds inert carrier	April 4, May 10	Inner leaves	June 15	1.1	500-gram sample
3 pounds DDT, 97 pounds inert carrier	April 14	Outer leaves	June 15	1.9	500-gram sample
3 pounds DDT, 97 pounds inert carrier	April 14	Outer leaves	June 15	1.6	Second aliquot of above sample
3 pounds DDT, 97 pounds inert carrier	April 14	Inner leaves	June 15	4.9	500-gram sample
Untreated		Composite of heads	June 15	0.05	500-gram sample
4 pounds DDT, 85 pounds sulfur	May 12, July 3	Inner portion	August 7	0.2	500-gram sample
4 pounds DDT, 85 pounds sulfur	May 2	Composite of heads	August 7	0.2	500-gram sample
Untreated		Composite of heads	August 7	0.05	500-gram sample. Slight yellow color in nitrated solution
Untreated		Composite of heads	August 7	2.0	500-gram sample. Should be same as above sample. Sample suspected
Green beans—sprayed					
5 pounds 20 per cent DDT wettable powder, 0.5 gallon Volck oil	August 14, August 21, September 3	Pods cut very fine	September 6	11.0	
5 pounds 20 per cent DDT wettable powder, 0.5 gallon Volck oil	August 24	Pods cut very fine	September 18	3.4	
Green peas—dusted					
5 pounds DDT, 95 pounds inert carrier	July 24, August 4, August 14, August 24, September 2	Pods	September 24	1.5	339-gram sample
3 pounds DDT, 95 pounds inert carrier dusted on same dates as above sample		Pods	September 24	0.7	209-gram sample

* Unless otherwise noted, 453-gram samples were used.

TABLE 37

COMPARISON OF NITRATION AND GUNTHER METHOD AS MODIFIED BY HOSKINS—RESIDUE FUSED WITH $NaNO_3$

Plant analyzed	Nitration method, p.p.m. DDT	Gunther method, p.p.m. DDT
Green beans	11.0	10.6
Olives	19.3	19.9
Olive leaves	169.0	160.0
Olive leaves	184.0	173.0

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